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ABSTRACT

For several years at the Rural and Small Schools Conference, a special effort has been made to address the needs that are unique to rural science educators. This publication is a compilation of materials presented at those conferences reflecting the following themes: "In Search of Excellence" (1985); "Rural Education: A Proud Heritage and a Bright Future" (1986); and "Rural Education: A Hope for the Future" (1987). The complete papers are included for the 1985 conference. The remaining two years have only the abstracts provided. Topics of papers included deal with: science skill objectives; science fairs; teacher education; professional development; science laboratories; biological concepts; and strategies for assessing strengths, needs and visions of science teachers in rural schools. The abstracts cover information on critical thinking skills; inservice workshops; the use of networks for the development of programs; science activities; application of a thinking model; the use of field sites; the use of community resources; telecommunications; use of computers in science; and science, technology and society. An index of authors is provided. (RT)

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SCIENCE EDUCATION IN RURAL AND SMALL SCHOOLS

Proceedings from the
Rural and Small Schools Conferences,
Science Education Sections: 1985-1987

Kansas State University
Manhattan, Kansas

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PREFACE

For the past three years, a special effort has been made at the Rural and Small Schools Conference to address the unique needs of rural science educators. Themes of each conference (In Search of Excellence; Rural Education: A Proud Heritage and a Bright Future; and Rural Education: A Hope for the Future) are reflected by the content of each paper. The success of this program is evidenced by the growing interest and number of presentations each year.

The following is a compilation of materials presented at the 1985-1987 conferences. For the 1985 conference, complete papers are included. For the remaining two years, only the abstracts are provided. The interested reader is encouraged to contact the author(s) for a complete paper.

Additional copies of these proceedings may be obtained from: The Center for Science Education, Bluemont Hall, Kansas State University, Manhattan, Kansas 66506, (913/532-6294). Please include $ 6.00 for postage and related costs.

Proceedings Editors

Sil Pembleton
Nancy F. Klefer
Emmett L. Wright

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IN SEARCH OF EXCELLENCE IN RURAL SCHOOLS

Seventh Annual
Rural and Small Schools Conference

Kansas State University
October 28-29, 1985

PAPERS

Science Education Section
Conference Co-Chairpersons

Dr. Larry G. Enochs
Dr. Emmett L. Wright

Science Skills Objectives

An Approach for Allaying Science Anxieties

in Teachers of Grades 4-6

Betty L. Bitner

Arkansas Tech University

Russellville, Arkansas

Focus on Science Skills Objectives:

An Approach for Allaying Science Anxieties in

Teachers of Grades 4 through 6

Recent educational research and proposals, such as The Paideia Proposal: An Educational Manifesto (Adler, 1982); A Nation at Risk (The National Commission on Excellence in Education, 1983); High School (Boyer, 1983); "Studies of Schooling. High School Reform: The Need for Engineering" (Sizer, 1983); Horace's Compromise: The Dilemma of the American High School (Sizer, 1984); and Place Called School: Prospects for the Future (Goodlad, 1984) seemed to echo the cry, "crisis in education," and simultaneously seemed to call for educational reform. Furthermore, proclamations by Futurists (Allen & Dede, 1979; Barnes, 1979; Buchen, 1980; Combs, 1981; Dede & Allen, 1981; Edmunds, 1979; Loye, 1979; Niebuhr, 1981; Shane, 1979, 1981, 1982; Shostak, 1981; and VanAvery, 1980) and findings of School Effectiveness Research (Anderson, 1982; Brookover & Lezotte, 1979; Clauset, Jr. & Gaynor, 1982; D'Amico, 1982; Edmonds, 1982a, 1982b; Firestone & Herriott, 1982; Gersten, Carnine, & Green, 1982; Ingrassia, 1982; Lasley & Wayson, 1982; Levine & Stark, 1982; Longo, 1982; Miller, 1982; McCormack-Larkin & Kritek, 1982; Murphy, Weil, Hallinger, & Mitman, 1982; Purkey & Smith, 1982; and Finn, 1984) supported the need for educational reform, the need for excellence in education. In his analysis of the research and recommendations for educational reform of the 1980s, Passow (1984) noted that the consensus of the reports seemed to be that education needs more rigorous requirements with an emphasis on general education and yet only The Paideia Proposal, the National Science Board Commission, and Goodlad devoted any time to the articulation of the curriculum K-12. Passow (1984, p. 681) asked, "Can more study in mathematics and science be demanded without building the skills required for more advanced study in those areas?"

This "crisis in education" has both general and specific ramifications. Specifically, the results of research in science education from the late 1970s to the present seemed to suggest a crisis in science education. These studies include three National Science Foundation (NSF) studies (Helgeson, Blosser, & Howe, 1977; Stake & Easley, 1978; and Weiss, 1978); a Dephi Study (Butts, D., Capie, May, Okey, & Yeany, 1978); National Assessment of Educational Progress (1977, 1978); Project Synthesis, the synthesis of the three NSF studies, (Harms & Yager, 1981); science education institutions and science educators (Gallagher & Yager, 1981; Yager, 1982, Yager, Bybee, Gallagher, & Renner, 1982; Yager, Hofstein, & Lunetta, 1981; and Yager & Kahle, 1982); the results of the 1981-82 National Assessment in Science (Hueftle, Rakow & Welch, 1983); and the Project for Promoting Science Among Elementary School Principals (Mechling & Oliver, 1982, 1983a, 1983b, 1983c, 1983d).

In response to this "crisis in science education," Yager et al. (1982) suggested an interaction between science, society, and technology. Project Synthesis (Harms & Yager, 1981) recommended four goal clusters (personal needs, societal issues, academic preparation, and career education/awareness) with emphasis upon science, technology, and society. Likewise Yager et al. (1981), Piel (cited in Harms & Yager, 1981) and Robinson (1982) advised that science education for the eighties should focus on the interaction of science, technology, and society in an attempt to address contemporary societal problems (Bybee, 1979 and Watson, 1982), such as population, energy, and pollution. Again, Yager (1984) advised that the role of science education is the cultivation of scientifically and technologically literate citizens.

Hurd (cited in Raizen, 1982) reported that elementary students received only an average of one and a half hours of science per week, that approximately one-third of all students dislike science by third grade, and that only about one-fifth of all students enjoy science by the end of the fifth grade. Perhaps adherence to several researchers' recommendations could help

alleviate this dilemma. For example, Okey & Buttes (cited in Rowe, 1982) identified a set of behaviors for science teachers: (a) competency in the subject, (b) effective teaching strategies, (c) ability to motivate the students, (d) good rapport with all students, and (e) regular sampling of students.

More specifically, Pratt (cited in Harms et al., 1982) delineated the following requirements for the elementary teacher: (a) experience and knowledge of both science process and content; (b) understanding of students' cognitive, psychomotor, and affective development; (c) understanding of the importance of science in the students' growth; and (d) command of teaching techniques such as groupings, questioning strategies, inquiry, and evaluation. In addition, he identified the positive features of instruction: (a) precise goals which are reflective of both the teacher's and students' needs, (b) ample time for science lessons, (c) cooperative interaction, and (d) use of science vocabulary in context.

The National Science Teacher Association ("An NSTA Position Statement," 1982) established the following criteria for elementary science: (a) a basic in the elementary curriculum, (b) a sequential and articulated program of both physical and life science with a hands-on approach to exploration and investigation, (c) inclusion of both science concepts and science processes, (d) activities to arouse the students' curiosity, and (e) cultivation in the students an understanding and appreciation of their world. Mechling & Oliver (1983d) explained the need and role of science as a basic skill in the educational process.

The State of Arkansas was not exonerated from the "crisis in education" and the "crisis in science education" in particular. In response to these "crises," Act 445 of 1983, the Quality Education act of the Arkansas General Assembly, established a fifteen-member Education Standards Committee which was charged with formulating new standards for accreditation of Arkansas public

schools. The State Board of Education adopted these standards on February 22, 1984, with compliance set for June 1, 1987 (Standards for Accreditation, 1984).

During the fall of 1983, the Arkansas General Assembly signed one hundred education improvement acts. Student testing (Act 58 and 59) and course content guides (Act 90) were two of those approved acts. Students in grades three, six, and eight will be tested on their knowledge of basics skills every year beginning in 1986-87. Retention of eighth graders who fail will be enforced. Appropriations for the development and dissemination of course content guides was $253,128 for 1983-84 and $52,944 for 1984-85 (100 education improvement acts signed, 1983).

The Standards for Accreditation of Arkansas Public Schools (1984, p. 3) outline the following broad areas for science for Grades 1 through 6:

(1) General Science

(2) Health

(3) Safety

(4) Conservation

(5) Nature study

(6) Harmful effects of alcohol, drugs, and tobacco

(7) Fire prevention

Pursuant to the adoption of the Standards for Accreditation for Arkansas Public Schools on February 22, 1984, two committees, each composed of public school teachers and administrators, state education personnel, and a higher education consultant were established to develop and write science skills objectives. One committee was concerned with grades 4 through 8; the other with grades 9 through 12. Prior to 1984, statewide science skills objectives were non-existent. Only four days were allocated for the skills writing.

This paper will focus on just Grades 4 through 6 science skills objectives. For each topic, science skills objectives at three instructional

levels (basic, developmental, and extensions) were formulated. The skills objectives are defined as follows:

1. The basic skills are those skills which all students must master. They are also the skills on which the Minimum Performance Test items are based.

2. Developmental skills are those skills beyond the basic level that should be introduced and taught, but not necessarily mastered by all learners. Often developmental skills at one grade level become basic skills for subsequent grade levels.

3. Extensions are suggested for those who have mastered the required basic and recommended developmental skills. Extensions stress the higher order thinking, processing and problem solving. (Arkansas Department of Education, 184, p. 1).

Minimum Performance Testing will be conducted in science at the end of Grades 6 and 8 and upon completion of three units of science (i.e., one unit of biology, one unit of chemistry, and one unit of physics) between Grades 9 through 12. This testing applies to all students except special education students who are required to meet the objectives as delineated on their Individualized Education Plans.

The science skills objectives for Grades 4 through 6 include topics in biological, physical, earth, and environmental sciences. In addition, both content and process skills are emphasized. The broad topics are as follows: science process skills; living and nonliving; heredity and change; human body; development of plants and animals; plant and animal behavior; plants; vertebrates and invertebrates; food chains; environment; rocks, minerals, and fossils; changes in the earth's crust; weather; universe; natural resources; pollution; water cycle; matter; elements, mixtures and compounds; acids and bases; air; sources of energy; heat; electric circuits; electromagnetism;

electrical insulators and conductors; concave and convex lenses; reflection and refraction of light; sound; and machines.

Since science was not a mandated curricular requirement in Grades 4 through 6 in the Arkansas Public Schools prior to the adoption of the Standards for Accreditation for Arkansas Public Schools by the State Board of Education on February 22, 1984, Grades 4 through 6 seemed to be the most critical area. Therefore, educators from Arkansas Tech University became engaged in planning and implementing area science workshops for elementary teachers during the 1984-85 school term. Subsequently, when the Education for Economic Security Act Grants became available, area school administrators, curriculum coordinators, and university faculty brainstormed with inservice elementary/middle school teachers to determine their science needs. It was the consensus that content, especially in the physical sciences, not methodology was needed. Therefore, two workshops, of three credit hours each, were planned to meet the science needs of several rural schools and one city school. Both workshops will attempt to allay the science anxieties so common among elementary teachers by focusing on the science skills objectives for Grades 4 through 6 in an attempt to prepare these teachers to meet the Standards for Accreditation.

The first three-credit-hour workshop was conducted at Arkansas Tech University during the summer of 1985. The duration of the workshop was five weeks or the equivalent of 45 class hours. For this segment of the grant, only physical science topics were covered. Also, rather than a team approach for the instruction, one public school physical science teacher taught all aspects of the workshop. Throughout the workshop, a hands-on approach was emphasized. The teacher presented background information and experiments on each of the covered topics. In addition, the six inservice teachers were responsible for outside readings, experiments, and examinations on each of the

topics. Upon completion of the workshop, all participants were reimbursed for tuition and room and board at Arkansas Tech University.

The next three-credit-hour workshop had a different format. This workshop commenced August, 1985, and continued until May, 1986. A very diverse group of 41 elementary/middle school teachers of Grades K through 7 enrolled in this workshop. Thirty of the 41 participants received reimbursement scholarships and travel expenses upon completion of the workshop, as provided by the grant. Their school districts will receive reimbursement for the substitute teachers needed during the teachers' absences due to workshop participation. The only cost to the school districts is a $50 per teacher fee. This fee was established as a way of getting some commitment from the school districts. The topics for the second workshop cover all topics in the science skills objectives for Grades 4 through 6, not just physical science. Therefore, a team approach for presenting the topics was utilized. The Project Director, a science educator at Arkansas Tech University, served as the principal liaison person, model teacher, and coordinator. Scientists at Arkansas Tech University served as workshop presenters and as on-line problem solvers working directly with the inservice teachers.

At the first session, the Project Director administered The Shrigley-Johnson Science Attitude Scale (Shrigley & Johnson, 1974) to the 41 inservice workshop participants. This Likert-type scale contains 26 items, with 16 positive and 10 negative responses. At the last workshop session, the scale will again be administered. the results of the pretest and posttest will be compared.

Since there are approximately 18 K-3 teachers enrolled in the second workshop, each presenter is expected to suggest ways in which the activity could be modified to meet the needs of younger children. This modification is difficult for some of the scientists because most of them have not taught

elementary children. Therefore, both the Project Director and the inservice teachers must provide direction for these scientists.

The workshop schedule (see Appendix A) was established around the school calendars of the workshop participants, the Project Director's and professors' schedule, and the workshop.

The actual workshop time is only 31 hours. In addition to this time, the workshop participants are developing individual projects in their classrooms. This approach was taken as one way of tailoring the workshop format to the individual participants' needs (Harty & Enochs, 1985).

The second workshop utilizes a lecture/activity based approach to instruction. The criteria for presenting an experiment or activity are as follows: safe, feasible, and appropriate for the elementary students. The teachers must have or be able to get the equipment or materials for presentation of the activities if we ever hope to allay their anxieties about teaching science. All instructors are utilizing the same experiments/activities form (see Appendix B).

Evaluation, both formative and summative, is an important component of the second workshop, but paper-and-pencil examinations will not be given. The evaluation procedure has two components: (a) workshop participation and follow-up laboratory reports; (b) a Unit Box (see Appendix C) or 20 experiments or observations (10 life science and 10 physical science). The second component of the evaluation procedure provides for individual needs and interests.

The focus of both workshops is, "Yes, you can enjoy teaching science and your students can become technologically and scientifically literate citizens ready for the 21st century!"

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Appendix A

Workshop Schedule

Physc 6883

8-28-85	10-12 a.m., 1-5 p.m.
	Dardanelle High School
9-27-85	7:30-11:330 a.m.
	McEver Hall, ATU
10-15-85	Evaluation of the workshop
	3:30-5:30 p.m.
11-21-85	12:30-4:30 p.m.
	McEver Hall, ATU
1-23-86	12:30-4:30 p.m.
	McEver Hall, ATU
2-7-86	8:00-3:30
	Field experience, etc.
3-13-86	12:30-4:30 p.m.
	McEver Hall, ATU
4-17-86	12:30-4:30 p.m.
	McEver Hall, ATU

Grading Procedure:

1. 1/2 workshop participation and laboratory reports
2. 1/2 Unit Box or 20 experiments or activities
   (10 life science and 10 physical science)

Appendix B

Science Experiments/Activities

Grades 4-6

Subject: Time Needed:

Skill Number & Skill:

Materials:

Sketch of Experiment:

Procedure:

Step 1.

Step 2.

Step 3.

Step 4.

Observations & Expectations:

Possible Problems:

Source:

Textbook Correlation:

PhySc 6883

Betty L. Bitner

Appendix C

Unit Box Assignment

N. B.: The lesson plans, references, letter to the parent, description of the unit box, and the background information for the teachers must be typed.

Unit Box Approach to Learning

One of the course requirements is the development of instruction for elementary school science. This unit should represent an activity approach to teaching. The purposes of your unit are to have students have opportunities to (1) improve their skills, (2) utilize the processes of science, and (3) improve their scientific literacy. Since many of the students you will be working with will be at the concrete operational level of thought development, the manipulation orientation is most appropriate. Your unit should require that children have confrontation with real things and real problems.

These directions are modeled after the concept of Unit Boxes of Mitch Batoff and Lloyd Barrow. Batoff and Barrow have published several articles on Unit Boxes. Some of the better sources are:

School Science and Mathematics 74: 667-799, December, 1974

Educational Technology 15: 9-17, May, 1975

Science and Children 12: 7-8, November, 1974

Current/The Journal of Marine Education 4:10-11, Winter, 1983

The following is a list of sources other than those by Barrow and Batoff:

Science and Children, 20(1), 1982, 18-20.

Science and Children, 21(6), 1984, 15-16.

Your unit will consist of the following integrated components:

1. Description of the Unit Box: title, grade level, brief description of each lesson, etc.
2. Background Information for the Teacher

3. Lesson Plans (8-10): behavioral objectives, set, data-gathering techniques, data-processing techniques, closure, evaluation techniques, content outline, and a list of materials and/or resources
4. One or more related Teacher's Guides (SAVI/SELPH Modules, textbooks, etc.) used as a starting point
5. Manipulative materials for each child or a group of children
6. A letter to the parent(s)/guardians to introduce the unit (An excellent source is Paul Beisenberz's article "Getting Parents Involved: Mission Impossible?" Science and Children, 17 (15): 9-11 February, 1980)
7. References: APA style (textbooks, trade books, etc.)
8. A set of record sheets or work sheets for pupils

*9. A tape cassette, associated work sheets, and manipulative materials

*10. A set of overhead transparencies

*11. Trade or library books for pupils (three or more with readability levels for each). The article "Integrating Science Activities Through Literature Webs," School Science and Mathematics, 82 (1), 1982, 65-70 describes a method of incorporating trade books into science. Another source is "Behold the World! Using Science Trade Books in the Classroom" Science and Children, 19(6), 1982, 5-6. Use the computer software in the computer laboratory.

*12. Potential source of field trip(s), resource speakers and/or audio-visual source(s) (Provide names, addresses, title, telephone numbers, and other pertinent information.)

*13. A set of vocabulary cards and a vocabulary game

14. Detailed bulletin board plans (2 copies)
15. Task cards for poor readers (at least three different cards). A source that will help you is The Reading Process: The Teacher and the

Learner, 4th Edition, by Miles V. Zinzt and Zelda R. Maggart, Wm. C. Brown Publishers, 1984.

16. A large sturdy box, smaller containers, and a file all labeled and organized for containing all of the above items. (The boxes should be motivational in nature.)

*A copy of the unit box topic, the target grade level, and the general goal of the unit box should be submitted by February 3, 1986.

Your unit box should contain all necessary material for approximately eight to ten science lessons. Each of the above 16 items will be evaluated upon its thoroughness and appropriateness for the target grade level of the activities. Your unit box will be due between April 21 and 30, 1986.

An All-Science Undergraduate Major Designed for Small School District Teachers

Darrel Hoff

Astronomy and Science Education

University of Northern Iowa

An All-Science Undergraduate Major Designed for Small School District Teachers

Like many of the basically rural states, Iowa's Small School districts face difficulties in securing qualified science teachers. Of Iowa's 450 school districts approximately two-thirds enroll 750 or fewer students (K-12). In such districts it is not uncommon to find only one or two science teachers in grades 7-12.

The University of Northern Iowa (UNI) is the one Iowa public university which emerged from teacher college roots. Although teacher preparation accounts for only about 40% of our current student body it seemed appropriate that UNI take the lead in this state in serving the special needs of small Iowa school districts. Ninety-six percent of our students come from Iowa and over 80% of our teacher graduates express a preference to stay in Iowa after graduation.

In 1982, we completed a follow-up study of our science education candidates who were teaching in Iowa. We used graduates of the three previous years as the basis of our study. We were particularly interested in comparing teaching areas where they had either received UNI science area approvals or separate (and less stringent) Department of Public Instruction (DPI) endorsements. They averaged 1.74 UNI approval areas, and had sought an additional 2.27 DPI endorsements.

As evidence that broad preparation in the sciences is necessary, these teachers reported an average daily preparation for 3.65 <u>different</u> subjects.

Based on this information the science education faculty began (what was to be) a two-year study to design and gain approval for an "All Science Major." The goal was to produce a major that would prepare teachers for possible employment in small school districts or as general science teachers in larger districts and meet existing state requirements to receive endorsement from DPI for all sciences.

Following our survey, we held a science education seminar to acquaint our science faculty with the nature of the problem. A study committee prepared plans for the "All Science Major" and each separate science department discussed the major in departmental meetings. A special meeting was held with DPI representatives and, following the usual curriculum process, the major was approved.

What emerged and was approved by the Iowa Board of Regents is shown in Table 1.

Insert Table 1 about here

Some remarks should be made. Surprisingly little opposition to the major was expressed by the science discipline departments. In answer to critics who viewed 16 semester hours of coursework as being too minimal a preparation to teach a subject, we could point to the fact that it is possible to obtain DPI endorsement with as little as 12 semester hours. In our follow-up study of recent graduates referred to earlier we found those teaching chemistry were doing so with an average of 13.5 semester hours and people teaching physics were doing so with 12.1 semester hours.

In a more recent study we found that earth science in Iowa is more often taught by a biology teacher or a physical education major than by an earth science major. In fact only 8% of the people teaching earth science in Iowa held an undergraduate major in earth science. Clearly the requirements for the All-Science Major are an improvement on current practices.

Is the program working? In spite of the fact that this major will just this fall appear in our university catalog, we currently have 12 declared All-Science Majors. Our plans include a follow-up study as these graduates reach the work place. For additional information feel free to contact me (319-273-2389).

Table 1

All-Science Major at UNI (1984)

Required	
Biology I and II	8 hours
Chemistry I and II or Condensed Chemistry	5-8 hours
Astronomy and Astronomy Lab	4 hours
Weather	3 hours
Physical Geology	3 hours
Earth History	4 hours
Physics I and II	8 hours
Orientation to Science Teaching	2 hours
Science Teaching Colloquium	1 hour
Two courses from	
Current Curricula-Chemistry	
Current Curricula-Physics	
Current Curricula-Biology	
Current Curricula-Junior High Science	4 hours
	42-45 hours
Electives	
Biology	8 hours
Chemistry	8 hours
Earth Science	2 hours
Physics	8 hours
	26 hours
	Total 68-71 hours

Note. Elective courses must be those that count toward major in that discipline. Must include 12 hours at the 100 level or above (Junior-Senior level) with three hours at 100 level in each of three disciplines of science. Mathematics prerequisite of one or more of required courses in algebra and trigonometry.

SCIENCE FAIRS IN RURAL AND SMALL SCHOOL SETTINGS

Ron Hughes
Kansas State University

SCIENCE FAIRS IN RURAL AND SMALL SCHOOL SETTINGS

Education in general, and science education in particular, is often assumed to be inferior in many rural and small school settings (Colton, 1981; Sher, 1977). However, a report of the National Assessment of Education Progress Test (Martin, 1979) indicates the contrary when science test scores of students from rural settings are compared to national scores. A science fair conducted in either an urban or a rural school setting exhibits many of the same characteristics. Those characteristics which are unique to each setting should not be regarded as unfairly advantageous or overwhelmingly handicapping to individuals interested in implementing a science fair in either setting.

Science fairs have been a part of education for nearly half a century. In the 40's and 50's "the scientific method" was encouraged as the approach to science in classrooms and student projects focused upon displays of technology: models of rockets, satellites, planetary systems, ant farms, volcanoes, and the like. In the 1980's, the emphasis in science fairs has been the "process" of scientific investigation. Students are presently asked to approach a problem (new or unique, at least to the student) in a scientific manner. Experiments, as always, are to be clearly defined, carefully controlled, and reasonably repeatable. Investigations into new theory should be conducted with consideration of alternative explanations for the phenomena being studied. New approaches to solving old problems are encouraged, even though the process may not follow, step-for-step, the regimen of "the scientific method." Science fair projects which investigate problems in the social sciences have gained some recognition of acceptance in science fairs, however, reports of surveys (e.g., Which cola was preferred by fifth grade students?) are more often regarded as "weak projects" with respect to the "process of science."

Most science fairs, whether conducted in a rural or urban setting, provide for desirable educational experiences seldom available in the education entirely restricted to the classroom setting. Science fairs, in general, provide a wide

variety of desirable education experiences. Students may work individually or in teams in their approach to solving a problem. Family learning can be employed when parents or other relatives are allowed to participate by providing additional guidance to the student. And, when time and resources allow, the student is given the opportunity to synthesize his or her experience in a written report and oral presentation, a high-level thinking process. The benefit of informal learning takes place when the student takes the investigation outside the classroom walls. And most important, the student is provided with the opportunity to become involved in the entire process of a scientific investigation from the concept of a problem to the application of the results.

In an effort to provide a "meaningful" education, curriculum developers try to provide experiences which reflect the cultural background of the students. Urban schools, because of their usual close proximity to colleges, universities, major businesses, and industry, tend to have easier access to resources of information and sophisticated equipment. Rural schools, on the other hand, generally have easier access to natural areas (Colton, 1981). The characteristic differences between the urban and rural school setting are insignificant with respect to their influence upon conducting a science fair for most elementary school settings. As the complexity of a science fair project increases with older students, however, certain issues do need to be addressed by the educational community.

Two factors, individual differences among students and instructional strategies, play the greatest role in providing for the best possible science fair experience; not only between rural and urban settings, but within each setting as well. Fortunately, there are also numerous strategies for science instruction which may address these student differences. Through implementation of appropriate instructional strategy, compensation can be made for those inequities which may exist between the urban and rural student settings. Where the urban school student may have numerous opportunities to make local calls for

information, the rural school student might have to incur expensive long-distance charges for the same information. It becomes the educator's responsibility to provide alternative resources for information for the otherwise handicapped student.

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Preparing the Secondary Rural Science Teachers

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Preparing the Secondary Rural Science Teacher

> Teacher education programs continue to turn out teachers who have only the vaguest awareness of the unique problems and potentials of small rural schools and communities. Moreover, these teachers have no special training to help them deal with the special characteristics of such schools and communities in educationally effective and personally satisfying ways.
>
> --Massey and Crosby, 1983

As a teacher in a small rural school for five years, I became keenly aware of this shortcoming of teacher education programs in preparing rural teachers, and have had ample opportunity to reflect on ways that such programs could better prepare the prospective teacher. In this paper, I will discuss some of the realities of teaching science in a small secondary school, and offer suggestions as to how the teacher preparation programs might better meet the needs of secondary science teachers in rural schools.

Nachtigal (1984) points out that the rural community offers a unique setting for schooling. It follows that rural teachers will encounter unique potentials and problems that teacher education programs should equip them to deal with.

I worked in a small high school in Custer County, Colorado, teaching earth science, physical science, physics, chemistry, health, and coaching the girls' volleyball team and the boys' basketball team. It is from this experience that I draw to discuss how a teacher working in the sciences in a rural school might be better prepared.

Train Generalists Rather Than Specialists

> A strong case can be made that rural schools need competent generalists more than a variety of specialists. Perhaps an analogy from the medical profession is appropriate here: A rural community does not need a neurosurgeon nearly as much as a family practitioner.
>
> --Carmichael, 1982

A teacher working in a rural school may need to be able to work with students of several different age groups. During one hour in the day the teacher may work with a seventh grade life science class followed by a senior physics

class. This requires the skill to make adjustments from one age group to another.

The rural teacher will frequently have as many as four or five different preparations each day. It is not practical to certify someone who will be a rural science teacher in one area such as biology. The biology teacher may find that he is also asked to teach earth science, chemistry, and possibly physics in addition to biology. The science teacher in a rural school must have a general background in each of these content areas.

Develop Rural Science Teaching Skills

The rural setting offers many possibilities and advantages to teaching science. The prospective teacher must be trained to make maximum use of the rural settings. Colton (1983) writes about teaching science in rural schools: "These skills (basic science skills) can be taught as well, if not better, by using the rural environment as the content instead of, or in addition to, traditional textbook content."

To develop rural science teaching skills, teacher education programs should train the prospective teacher to use the rural environment. This should include methods on how to use the environment for field trips, and how to use resources that are appropriate to the rural setting such as county extension agents, geological surveys, fish and game departments, and rural industries.

The prospective teacher should be trained to adapt the science curriculum to the individual school district. There is a lot of variation in rural communities across the country and the curriculum should be adapted to take advantage of the uniqueness in each community. The students in a rural area are already familiar with their environment and eager to learn more about the area in which they live.

Rural students have unique experiences that can be used to enhance the understanding of science concepts. Any student who had an opportunity to work

on a farm develops an understanding of living things and machinery that his/her urban counterpart is likely to lack. The rural science teacher should be trained to take advantage of this background understanding to teach science concepts.

One of the problems that I had to deal with at Custer County was a lack of time to do all the things that I wanted to do. With five preparations in science it is difficult to find time to do a job that is educationally effective and personally satisfying. Teacher preparation programs should help prospective teachers develop time management skills.

Science teachers need to learn how to organize laboratories and laboratory supply rooms so that laboratory preparation time is minimal. Adult and student aides could relieve the teacher of some of the routine burdens such as grading papers, typing, and preparing solutions. Teachers need to learn how to use this valuable resource effectively. Finally, the microcomputer will be a major time-saving device for the teacher who knows how to use it. Computer literacy should be a requirement for all preservice teachers.

Develop Skills for Living in a Rural Community

Another major area of concern that can develop into a real problem for some newcomers to a rural area is the social isolation which rural living may entail. A first-year teacher in a small town may have a difficult time adjusting to a rural lifestyle after having spent four years in a college or university town. Teacher education programs can help the rural teacher make the adjustment to a new environment.

The adjustment to a rural life-style could start early in the teacher preparation program by providing some type of visitation for the prospective teacher. Martin and Wood (1984) report that a program of this type has provided participating students with a rewarding experience. This could enable the prospective teacher to actually experience the close relationship that exists between a rural community and its school. At this early stage,

the prospective teacher could begin to learn ways to take advantage of the resources available in a small community.

Provide Support for Rural Science Teachers

A final area of concern for the rural science teacher is the professional isolation experienced in addition to the social isolation. In many rural high schools there is only one science teacher. The rural teacher frequently does not have the support that is needed, or someone with whom to discuss mutual concerns.

Teachers' education programs should help to provide some of the support for rural science teachers. This professional support would help to ensure that quality educational personnel are working in the rural schools. The state of Kansas is in the process of developing an internship program for the first-year teachers. As reported by Castle (1984), "The proposed internship program would provide a sound support system for ensuring teacher quality throughout Kansas schools." This program will ease the transition from university student to classroom teacher and provide the kind of support that is often lacking for a first-year teacher.

Continued support could also be provided through a university-located science education center. This center could provide many services helpful in overcoming the professional isolation experienced by rural science teachers. For example, the center could provide an inservice program and offer refresher courses. In an area that changes as rapidly as science, a teacher needs to be kept abreast of recent developments.

When a problem is encountered by a science teacher, it is advantageous to be able to discuss the problem with another science teacher. The university science education center could provide the "other" person by establishing a hot-line that the rural science teacher could contact when a problem arises. This hot-line could be staffed by graduate students who would be able to

discuss the question with experts in the field, and then return the call to the teachers to help solve routine problems that are encountered in teaching.

The science education center could publish a periodic newsletter to keep rural science teachers informed of developments in science, and provide a vehicle to share their ideas and experiences with other teachers.

The science education center could also provide the rural science teacher with resource people to advise, develop, modify, adapt and improve science instruction and curriculum. This type of professional support is frequently unavailable to rural science teachers and can provide a mechanism for the improvement of the quality of science education.

One final way to overcome professional isolation of rural science teachers is through the use of rural clusters to establish peer support groups. Regular meetings can be scheduled through the clusters to enable the rural science teachers to discuss items of mutual concern. Having periodic contact with peers not only is an excellent way to learn of new ideas that will benefit the students, but helps to motivate teachers - which is so important to effective teaching.

Conclusion

In this paper, I have discussed the ways that teacher education programs might have more adequately prepared me to meet the challenges of secondary rural science education. The rural science teaching situation is different in many ways from the urban situation. Teacher education programs in colleges and universities that serve rural areas and states must take these differences into consideration when designing teacher education programs.

A teacher education program must realize that the teachers who work in rural schools will need to work with several age groups and with multiple preparations. There are specific science teaching skills that are relevant to rural schools, and the prospective teacher should begin to develop these skills as a preservice teacher. Living in a rural area may require an

adjustment for the new teacher, and teacher education programs should provide training to help ease the transition from university student to secondary rural science teacher. Finally, continual support from the university through programs such as science education centers could help overcome the professional isolation that the rural science teacher experiences.

I do not pretend to know all of the answers to improving preservice teacher education programs and make them more relevant for the rural science teacher. I hope that the universities that serve rural areas will consider the suggestions and use them as a starting point for future research and development in their programs. Ultimately, I expect that the science teachers who eventually take a position in a secondary rural school will be better equipped to do the job effectively, and this will improve the quality of science education for students in the rural schools.

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Laboratory Science for a Small School:
A Decade of Overwhelming Success

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Laboratory Science for a Small School:
A Decade of Overwhelming Success

Introduction

How does one adapt existing science curriculum material to meet the needs of a small school? Which approach to science is appropriate for elementary children? How shall limited funds be spent? Should we buy books? Should we buy equipment? What type of equipment enables us to have the most successful program? What shall we use as a criterion of success for a science program?

In the limited time available today, I will touch on three areas:

1. The structure of the school
2. The structure of the room
3. The structure of teacher interaction.

Time will not allow thorough examination of these areas. A few highlights will be given here.

Elementary schools typically have self-contained classrooms. Teachers spend most of their energies on the development of language arts activities. Rarely do schools divide teacher tasks so that teachers have the luxury of focusing time on subjects other than language arts. Occasionally large schools assign one teacher to science - but this is the exception rather than the rule.

The Structure of the School

Can a small school redistribute teacher time to allow for the development of subject matter focus? Seattle Country Day school has done exactly this. The educational setting is a private school serving approximately 200 students from age four to fourteen. Above grade three, students move from classroom to classroom (similar to a high school) to study each subject. Classes contain no more than 16 students. Each class contains students who by age would be found in two or three elementary school grades, but who are assessed as being somewhat homogeneous in academic skill level. Instead of having grades four,

five, six, seven, and eight, we have five classrooms which focus on Language Arts, Social Studies, Science, Mathematics, and a split program for art-computers-physical education. There is a fluctuation in enrollment from year to year so that not every grade has an equal number of students. Grouping by subject matter has two advantages:

1. Teachers are able to focus their energies on developing lesson materials within a single subject area.

2. Despite fluctuation of age distribution, students are placed in classes of relatively uniform size.

We recognize that language arts skills are a primary concern in the elementary years. Grouping by subject matter specialty does not detract from this emphasis. Rather, subject matter focus allows language arts to be presented with a different emphasis within the contextual framework of each subject. Language arts classes focus on the usual areas including spelling, literary analysis, sentence and paragraph composition and reading. Social studies entails the writing of reports, reviews and papers. Mathematics requires the usual written calculations. Science incorporates extensive note-taking during lecture-discussion each day. In addition, students compose 10 to 20 page units of laboratory write-ups on a given theme each month.

Our science program is unusual. Textbooks are not used in science. Students understand that reading about science is not the same as being involved in the science process. Science has a special emphasis on note-taking skills not found in the typical curriculum. Students in our middle school program do more writing in science than in any other subject. Dittos are not used. Students must rapidly record comments made in class discussion and they must write directions for laboratory activity written on the overhead projector during the first fifteen or twenty minutes of class. When they go to their laboratory stations, students must record observations and numerical data and they must frequently prepare graphs. Student interest is extremely

high in laboratory activity. Students comply with the note-taking requirements because they know that they will not be allowed to go to their laboratory stations without the required written information and without prepared data tables in which to record observations. Rather than plodding away at written tasks, they complete the notes promptly in order to allow more laboratory time.

Neatness is not a major focus of this note-taking activity since students write as rapidly as their hand muscles allow. At first, students are told their goal is to get as much recorded as they can. No one who writes continually can fail. As the years progress, student handwriting becomes much better and their accuracy in recording comments of others increases substantially. Note-taking becomes an expected and accepted part of the process of science.

Our science program is the major selling point of our school. A private school is different from a public school in that viability is maintained by successful programs. However, the cash-flow stability deteriorates if the program is unable to attract students. Public schools exhibit a remarkable ability to continue existence despite unpopular and even unproductive programs. A private school must visibly market excellence. Our laboratory oriented science program is perceived to be rigorous, exciting and worth the tuition cost. The school has grown from a student body of 72 students ten years ago, to 208 students today. We currently have a substantial waiting list of students wishing to attend the school. Tuition has increased in keeping with the economy and is currently over $4,000. A new building was constructed from donated funds specifically to house the science-math program. These changes are hallmarks of a successful program.

The Structure of the Room

Half of each daily 55-minute science period is spent at writing desks in a central location. The other half of the period is spent in activity at

laboratory stations. In the middle school, each child has a laboratory station where equipment may be left.

The Laboratory Setting

In previous rooms (over the past ten years) laboratory tables were built from reject doors and had 2x4 legs. Currently we use recycled study carrels from our local university. From a local community college, we obtained recycled experimental tables (3'x5'), which have been divided down the center, with kindergarten tables up-ended and used as partitions. All students have space to work with a partner. Occasionally a student will request to work alone. However, many of the tasks are specifically designed to need two sets of hands to obtain the data. Groups of more than two are rarely possible due to intentional space limitations.

Some students strongly request working in groups of three. I have found that these students are people-oriented students who take delight in getting things done efficiently and in learning from others. They would prefer not to manipulate the equipment but rather to watch others do it so they can quickly determine the answer. These students have considerable facility with language and usually volunteer to write down the findings. They are typically unable to judge the significance of experimental manipulations which did not seem to work. They are skillful at guessing what a teacher is thinking and in predicting what the "correct" outcome of an experiment should be. They are not interested in trying to make the experiment work in a variety of ways.

On occasion a student will ask to work alone. It is often hard to find enough equipment for extra lab stations. It is also hard to find workspace because all stations are "owned" by partners. The type of student who wishes to work alone is usually a "tinkerer." These students are usually much more leisurely in their approach to the task. This is not to say that they waste time, but rather that they consider alternative ways of setting up equipment. This type of student is so interested in the structure of the equipment that

they do not wish to negotiate democratic ways of trying things. They wish to try experiments their own way and they frequently wish to design several methods. When a method fails to produce results, they prefer to go back over the apparatus to find where the problem occurred. Other students simply wish to start again so they can determine the answer. This type of student may fail to record all of the data points and may neglect to jot down interesting observations without considerable teacher encouragement. This type of student is interested in the task and not particularly interested in communicating the results to others. The student usually has a good sense of the relevance of procedures and uses imagination in designing operations. This type of student is often a very insightful member of the class discussion, showing understanding of the relationship between experiments.

Several arrangements of equipment at individual laboratory stations have stood the test of time. Over 29 years of science teaching I have experienced very little breakage and no serious accidents.

Each type of activity has a region where human clumsiness makes messes likely. After a few years of posing such tasks one may anticipate these little "disasters." I never criticize a student for breakage because I have never observed it to be intentional. I do all of the clean-up personally. The student has the responsibility to call me over to help when the accident occurs. The act of admitting the problem is traumatic enough for most students. They try to assess what happened and attempt to avoid the difficulty again. Most spills occur because the student has not learned to <u>pay attention</u> to the physical world and has not developed a set of expectations concerning how materials interact. Most of the spills come from students who have developed a strategy of getting information from humans rather than from paying attention to the physical world. If we wish them to gain confidence in their interaction with physical objects, we must not give them criticism from

humans. The "criticism" of the spill is direct communication from the physical substance.

In order to avoid spills, I hand out chemicals in small pill bottles which resist tipping. Tiny test tubes are often taped to small boxes for support. Students perceive that they are getting far larger amounts of chemical than they actually are.

I use a great many disposable petri dishes. These are "things" of science that lend importance to the activity. Eyedroppers and small containers are to be set in petris so that drips do not make lab tables overly slimy. Students are upset when their notebooks get wet. Petris are also used as component parts in mechanical devices. They are used as end caps for rolls of house-gutter screen used to make bug cages. Whenever a circular component is needed, a petri may be used.

Alcohol burners are very attractive to students. Fourth grade students are quite anxious about lighting matches and they find daily burner usage very glamorous. I have found burners to be extremely safe in the classroom when certain rules are enforced. Each lab station may have a "match petri" which consists of a petri with strike plate (cut from the side of a box of kitchen matches) taped to the lid. Three matches per petri seems to be about right - the rule being that they do not want more fuel than the size fire they are willing to put out. The other component of safe use of fire is a "fire-extinguisher" beaker. (Again, I use "things of science" as often as possible.) When a match is lit, one is faced with the task of putting it out. Students are skittish about dealing with flames and need careful instruction about how to get rid of it. A beaker of water located next to the match petri provides an ideal place to drop the lit match. Some students have the presence of mind to blow out a match, but most of them prefer to simply drop it after lighting the burner. Most students of the fourth and fifth grade age need instruction on holding a kitchen match horizontally to avoid burning their

fingers. In an effort to gain distance from the flame their immediate response is to point the match down - thus centering the flame on their hand. The "fire-extinguisher" beaker also serves as an immediate source of water to put out flames which become too large for comfort. Additionally, they are a reservoir of cool water for immediate treatment of burned fingers. The children understand the three uses of a "fire-extinguisher" beaker; however, they rarely use it other than to collect used matches. Knowing what to do seems to prevent accidents. I never light burners for students, but I stand nearby and watch each laboratory station as they light matches - at least for the first few weeks of use. Students call me over when they are ready to light.

Although many science projects call for candles, I consider them very dangerous to use in the classroom. Students collect wax in hidden stockpiles. They love to cover their fingernails with was. Wax drips on the floor, making it treacherously slippery. In addition, candles give off sooty fumes which make the atmosphere in the room very unpleasant. Alcohol burners have a much cleaner flame and do not cause students to do unsafe childish things. Students are required to wear goggles (which are rather scientifically glamorous) when they use chemicals - including alcohol in burners. I use candles in the classroom only to confront students with their understanding of chemical vs. physical change. After challenging them to see who can burn a candle fastest, I find students melting candles over tubs of water. The next class discussion is always rousing when students are confronted with their perception that "candles don't burn -they melt!" Candles are also useful as a glue to attach nails to metals in heat conduction experiments.

An alcohol burner used with a lab stand holding wire gauze and a beaker of water is a common sight in our science room. We have found many uses for this equipment; for example, a great many hours of experimentation are needed for students to generate heating-cooling curves. Thermometer breakage is very

common in many science rooms. I have not had a single breakage in 29 years of teaching science labs. I never allow students to hold a thermometer. I personally hang each thermometer from a ring on a lab stand, using a pipe cleaner. Students may move the ring up and down the rod, but they may never take the thermometer off. The pipe cleaner allows them to twist the thermometer so they can view the liquid and they have freedom of motion to place it in and out of beakers. Before a parent fund-raising activity purchased lab stands, I hung thermometers from pegboard backing attached to lab stations.

Water tables and water flow experiments are extremely important activities. Floating and hydrostatic pressure are not simple ideas. A great many experiences are needed to bring students to an understanding of implied forces in water. One of the most useful water containers I have found is the long narrow container used to dampen wall paper. They are light weight and disposable. They are particularly nice for water squirting activities done indoors since a meter stick fits along the lip. I can usually get several years of activity out of them. After they tear I use them for sand experiments - such as examining the strength of tunnels. When holes are punched in one end for water to flow out, they make convenient containers for outdoor study of the aging of rivers. I can buy them locally for about 50 cents each. A wonderful adjunct to the wallpaper tub is a Clorox bottle with a cap with a hole punched near the base to use as a water source. Another fine device is dryer venting taped to a foam cup base (with a row of holes out of which water may flow) to examine the effect of water depth on spurt distance.

Laboratory balances are another frequently used piece of equipment. Originally, students each constructed straw balances and examined stability and sensitivity caused by the location of the fulcrum. Recently, parent fund raising activity has allowed the purchase of student balances - which cost $100 each. There are advantages to the use of each type of equipment depending on the intent of the unit. I try to have students measure using

meter sticks, graduates, clocks and balances as often as I can. Precision and variability in data collection provides the framework for debate each day.

Perhaps the most useful material is masking tape. Children need to assemble component parts each and every day. Their structures are usually unstable and temporary, but they provide a glimpse at the type of data that would be possible if they had used "fancy" equipment. Masking tape empowers the mind to imagine what the scientific tool of the adult would be like while making the imprecise approximations of the child. It is safe and inexpensive.

A great many other materials are used in laboratory activity. I have developed six years of daily activity including:

a year considering forces such as adhesion, cohesion, gravity

a year of earth science

a year of simple chemistry

a year of simple physics

a year of physiology from an engineering point of view

a year of materials science

The Discussion Setting

Science has been held in several different rooms as the school has changed over the last decade. In each setting, a portion of the room was organized for class discussion. There seem to be specific seating arrangements which facilitate class debate - and specific arrangements which interfere. I have been less successful in developing inquiry dynamics with 6th, 7th and 8th grade children seated in rows or clustered at tables than when students are seated at individual desks in an amphitheater arrangement. If it is necessary, two students may be seated at a table provided they both face the overhead projector and the screen. I have found inquiry more difficult with more than two semi-circular rows unless tables at the rear are elevated tables with high stools. Changing the elevation of class members allows children to see each other as they debate issues. For the type of

intellectual interaction described in the next section of this paper to occur, students must face all others in the room. Distance is important. If students are across the table, they begin individual conversations at the periphery of the class. If space across the room is too large, students do not reply to each other individually. I try to tape-record class debate. This helps students to wait until another student has finished making a comment before they make one - although the urge to encode ideas verbally at the moment of inspiration causes some overlap of speech. Tape-recording comments lends status and dignity to attempts to formulate a theory. Adolescent students must feel psychologically safe to be willing to risk proposing ideas which turn out to be wrong. The act of reasoning must be valued above the correctness of reasoning in order for cognitive growth to occur.

The overhead projector is in the center of the room because on it the teacher records what is said by various class members. Students are required to enter these comments into their notes. Some have difficulty remembering what is being said as they try to recall how to spell words. Having the dialogue placed on the overhead screen models the required behavior and shows that it is possible to record ideas at this fast pace. It further shows how comments may be shortened for purposes of note taking and, of course, it provides assistance in spelling of words. Additonally, the teacher recording of comments on the overhead helps students to speak slowly enough to be heard and understood. Students learn to limit their comments to the central issues which are written down. Note taking on the overhead projector thus is a useful device for revealing to students when they are off the central issue. Such comments are simply not written down - without comment or criticism. Clues about central issues and data from which to develop reasoning are thus continually at the center of visual attention (on the overhead projector).

Data are collected from each laboratory station (and written in a data table on the overhead projector) and then analyzed. Analysis of data and

reasoning with peers about the implications of the data are necessary for the development of logic in the child. It is quite possible to have "hands-on" activity without experiencing the scientific process. It is not simply a matter of allowing a student to investigate materials, but a science classroom must establish the conditions in which the child can organize these first-hand observations in a way that leads to meaningful interpretation. It is important to distinguish "show and tell" from scientific debate. The distinction may seem subtle, but it is the single most important difference between good, interesting science in the intermediate grades and a trivial activity period. Interestingly, children know the difference. Rigorous debate maintains the feeling of importance of the science process. (The major weakness of science fairs is that they overlook the importance of social collaboration for the development of reasoning in each individual).

Piaget states that this critical interactive experience where children communicate with each other is an essential factor in intellectual development. Science discussion can not be implemented in this way in the primary years because the children have difficulty conceiving of any point of view other than their own. Show and Tell activities are designed to emphasize expression on the part of the presentor without the necessity of others rebuilding or accommodating their point of view.

The Structure of Teacher Interaction

A primary aged child recognizes the adult as an authority figure. The child is willing to be taught because there is an admission of the difference between child and adult.

An intermediate aged child is beginning to acquire power among peers. Attempts are made to resist control from adults. Teachers are not automatically held in esteem. Some teacher behavior has to convince intermediate aged students that learning from this particular adult will be worth their time.

Adult education is different still. Adults of all ages claim psychological empowerment. It is difficult for adults to accept the learner role. Collegial relationships and peer tutoring may or may not be effective interactions. Master teachers must provide some identifiably different information concerning the act of teaching in order to gain the interest of other adult teachers. Our teacher education is largely ineffective because we have so little understanding of the teacher-learner role between adults.

There are several teacher behaviors which develop unconsciously in master teachers. Explicit statement of these behaviors may aid inexperienced teachers to more rapidly establish a rapport with students.

Teachers Must Show Interest in Students

Adolescent students have a deep need to be liked. Most of their emotional energy is going into the examination of various types of friendships. In order to "earn" the right to teach a youngster, the teacher must evoke a friendship response in the student. The master teacher does this by glancing from student to student, pausing long enough to establish direct interpersonal recognition. For a brief period the remarks made in class lecture can be made to an individual student - as if teacher and student were in an individual conversation while others were listening in. With seats arranged in a semi-circle around the teacher (and the overhead projector) personalized eye contact is possible. A lot of emotional information is communicated by the nature of a person's gaze. Teachers should cultivate "friendly glances" which establish a liking for the individual who is focused on. What is to be emphasized is that the friendship is not centered on a person's clothes or attractiveness - but on a person's worth as an independent entity. If the goal of a science class is to cause students to pay attention to the physical world around them, then it is inappropriate to compliment students on their dress or appearance. What is important is to look directly at students as if their ideas were of value.

It is important to note that this interpersonal recognition does not stem from a need to be liked by the teacher. It takes a self-assured teacher to reach out to each student individually and communicate by focus of attention that they are valued. From the very first day of class, then, the center of attention must be the individual student and not the teacher. We have all observed dramatic pauses in orations or lectures which draw attention to the speaker while the speaker gazes at another individual. The act of friendly valuing of individual students is a subtle skill. It is vastly different from an actor on center stage.

The unspoken message of individual glances is not indiscriminate liking of all attributes of a student. Teachers' glances do not validate immature behavior. Instead, the student is given the teacher's attention when the student is behaving in an interested and mature manner. The teacher rewards the student's maturing intelligence and interest in reasoning about things. The reward is the attention focus of the teacher. In fact, this teaching strategy may become so developed that misbehaving students are simply ignored. Teacher validation comes only from intelligent interest in the subject at hand.

Amazingly, students respond to this behavior immediately. They can be heard commenting as they leave the room that they are going to like the class - no matter how difficult the course requirements.

Teacher Must Show Interest in the Development of Logic

This recognition of individuals and the expectation of intelligence from each individual student is particularly evident during class discussion. There is no artificial "wait time" needed because there is a genuine interest in intelligent communication already established by teacher eye contact. Teachers wait for students to make their comments and actively listen to what is said. A shortened paraphrase of the student's comment is written on the overhead for others to copy into their notes. Usually, the student's contri-

bution is tape recorded as well. The classroom reverberates with the expectation of intelligence.

A second type of respect is occurring during such interchange. The teacher is not only respectful of the potential intelligence of each child, but the teacher is respectful of the thinking modality of the child. Some students contemplate laboratory observations without the mediation of words. Other students use words to mediate their understanding. The teacher never calls on a student to answer a question - but rather invites them to comment. Only those ready to encode their reasoning in words are involved in speaking. There is an absolute respect for silent contemplation. The "flip side" to this issue is that quite frequently several students feel the desire to encode their logic verbally at the same time. The teacher then is constantly in the position of gently reminding them to wait their turn. Asking them to wait so their comments can be picked up one at a time on the tape recording helps to retain the mood of scholarly respect. Every effort should be made to avoid severe criticism for this type of interruption. While student participation must be sequenced so they may thoughtfully listen to each other, they must not be stifled so that they lose their train of thought. Ideas must be verbally encoded to be remembered. It may be neurologically important for a student to speak when a particular line of reasoning is created. The teacher must exercise mature judgment in deciding how much superimposed dialogue may occur in class. Rigidly waiting for another to finish long-winded comments may be as damaging as unregulated interruptions. It must be remembered that this exercise is not the same as an oral report in Language Arts. The comments will not flow in a linear manner. They have not been planned out in advance for the purpose of communicating clearly to a listener. The function of speech in this setting is to enable the speakers to understand the ideas that are occurring to them. The job of the teacher is to be genuinely interested in how human beings come to understand the ssues. The teacher values comments

from students not because they are "right" but because the process of developing logic is interesting.

This interest in developing logic is thus picked up by the student. Because the teacher values the student, the student is willing to be valued and taught. Because the teacher values the way students develop in their logical abilities, students come to value their ability to use logic. Student respect moves from liking and respecting the teacher to liking and respecting their own process of logic.

Once an interest in logical discourse is established in the class, it becomes psychologically safe to be wrong. Students all develop an interest in trying to follow a line of reasoning to its logical consequences. Students no longer "feel bad" if another student introduces data which contradicts the data they are using as the basis of an argument. A new line of reasoning is developed and followed. The class atmosphere has been fully transformed from a judgmental setting where students are "right" and "wrong" to one where everyone who tries to be logical is interesting.

Teachers Must Show Interest in Laboratory Activity of Students

This class attitude is amazingly energizing for all involved. Laboratory work takes on a new significance. Students who previously depended upon other people to provide answers now begin to take an interest in observing the physical world. They know how to play the "social" game. We have just changed the rules of the game and the socially aware students quickly recognize it. Because they are so sensitive to the social setting they are willing to play the new game. This is exactly what the science teacher had in mind with all the "hands-on" activity. Through the device of class discussion, more and more students are enabled to pay attention to happenings in the physical world about them.

The things we pay attention to are the things we come to understand. With an increased amount of attention focused on the physical world, under-

standing increasingly occurs. Students actually begin to like science. It has become interesting to them because they have become able to focus attention on it without constantly being concerned with spewing back "right" answers.

This is an amazing sequence of events - and this is what teaching should be all about. If this is not the central function of a teacher, students may as well stay home and watch nature programs on TV. To summarize:

1. The teacher looks interestedly at students and thereby communicates a liking for individuals. Students respond by liking the teacher and by being willing to be a learner.

2. The teacher interestedly and respectfully listens to students develop lines of reasoning. Students reflect the teacher interest by becoming interested in and respectful of their own developing abilities to reason. Students also exhibit interest in the reasoning of other students.

3. The teacher exhibits interest in whether lines of reasoning are able to be tested with our unsophisticated lab equipment. Students reflect teacher interest by becoming interested in observing physical happenings in the laboratory setting.

4. By feeling valued and by becoming interested in reasoning and in observation of physical phenomena, students become interested in the study of science.

Science is a favored subject in our school. I believe it can be so in any school. Money is not the key to successful science programs. The key is an understanding and knowledgable teacher who values the development of logic in each child more than trivial messing around or simple memorization of scientific terms.

Beyond being a favored subject, our research suggests that science presented in this manner substantially increases the reasoning verbalized by

students. Additionally, it increases "on-task" behavior from 40% of class time to nearly 80%.

Daily laboratory science is, in our opinion, worth the time and effort because it is enjoyable, it significantly increases a child's use of reasoning, and it promotes task oriented behavior from all students.

Strategies for Assessing the Unique Strengths, Needs, and Visions of Rural Science Teachers

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Strategies for Assessing the Unique Strengths, Needs, and Visions of Rural Science Teachers

Historically rural education in general, and science education in particular, have either ignored the unique needs of rural societies or have viewed them from a deficit stance (4, 9). It has been assumed that the rural school with its limited resources is inferior to its urban counterpart. The curriculum, textbooks, pedagogy and standards of excellence created for urban school models have been used in rural schools as well (12). The use of these urban standards places rural schools at a definite disadvantage. We can no longer continue to attempt to make rural schools into urban schools.

According to Nachtigal (9) it is time for a new emphasis in rural educational reform based upon an acceptance of rural reality. Rural science education should reflect the unique and diverse strengths and weaknesses of rural life. Rather than being consumers of urban developed programs, rural teachers should learn to become developers and adapters of alternative models of curriculum and instruction that more appropriately fit their rural communities. Efforts must be made to assist science teachers to identify their specific local needs, to match these needs with community and school strengths and to use this assessment to build a vision of the future for their school's science program. However, if we are to propose such action it is essential that qualified science teachers be involved at the local and regional levels. These teachers should be highly competent both in science content and methodology and in the area of leadership and staff development. Teachers possessing these characteristics are not common; but outstanding science teachers are present on the rural scene and can be identified and trained in these areas. Such an effort is currently being conducted in a Midwestern Land Grant University program for middle and high school science teachers through a grant from the National Science Foundation.

Project Description

In February 1985, the National Science Foundation funded a project to identify, honor and train outstanding rural science teachers in order to create a pool of excellence in teaching with the ability and skills to help others. The participants were drawn from a group of 141 school districts in a rural Midwest state. These districts are located outside the sphere of influence of cities with populations over 100,000 and have less than 600 students K-12.

Selected teachers participated in a two-week summer training session involving instruction in the areas of science, science education and staff development. In particular, the science component concentrated on biology and astronomy within the context of space technology. This week of instruction took place at a nearby space science museum. The science education and staff development components were delivered the following week on campus. Science education focused on conditions for good science teaching and included current research findings, curriculum and methodology appropriate for rural science programs. The staff development instruction incorporated the fields of school improvement and leadership preparation.

The focus of this training was to prepare participant teachers to become leaders of rural science education improvement in their own schools and districts. Project participants were encouraged to assess their own specific local needs and strengths and to utilize this knowledge to create a personal plan, termed "Action Plan," for the improvement of science education in their community. Implementation assistance was provided during the following year to enhance the science improvement efforts of teachers participating in this project.

Assessing Needs

This rural science improvement project began with a multistage analysis of needs. These stages included the completion of an open-ended essay and follow-up survey which led to the development of site specific models. This assessment of needs provided the framework for project training and individualized plans, or visions, for improvement (see Figure 1).

This unique approach to needs analysis was developed because science teachers in the rural setting have needs that are different from teachers in larger schools in close proximity to large population centers. There is a tendency for small schools to adopt the same programs in science and to implement them in the same way as larger schools, without regard for the differences in the children's rural life experiences. Rural science teachers are frequently isolated from their peers and have difficulty in traveling long distances to professional meetings, thus making it difficult to exchange ideas in their field. These teachers often have to function in more areas than their larger school counterparts, and this sometimes results in inappropriate assignments and often results in work overload. This is particularly true in sciences where teachers sometimes are working outside their fields of strength (10). Rural teachers face many additional problems related to scarcity of educational resources in terms of people, places and materials available for science instruction. These needs are often not reflected in improvement efforts for science education.

The difficulty with assessing rural needs is best described by Nachtigal (9): "Public policy, both state and federal, has set about defining rural education's problems from a position far removed from the local community, using a set of standards much more applicable to large school systems than to small. In fact, many of the deficiencies of small

schools relate to size and, therefore, cannot be eliminated by definition. If the school cannot get bigger, it cannot get better" (p. 302). Nachtigal goes on to state that "If rural education is to be improved, it will be because rural communities define their problems in ways that make sense to them" (p. 304). McLaughlin's (9) review of rural school improvement efforts revealed that the success of rural school improvement seems directly related to the centrality of the problem to the school and community.

Keeping these issues in mind, the first step in this project was to facilitate the identification of areas of group need for training. An open-ended essay was required of applicants asking them to describe problems of science education in their community. The resultant discussion responses were a more accurate reflection of community conditions than predispositions on the part of project staff would have been. Traditionally, needs assessments consist of such predispositions and notions and subsequently do not reflect real needs.

From the responses gleaned from the open-ended essay, a study specific needs sensing survey was generated. The survey items were broken down into the three areas emphasized in the project: science, science education and staff development. These results were used to provide state of the art training that related to the specific needs of the participants.

Based on the information provided in the training sessions, the teachers were asked to develop their own models of improvement of rural science education. These models provided the foundation for a more in-depth individualized assessment of the science education needs in their communities. Participants analyzed their own district practices in terms of personalized desired ends. The focus on this activity was on developing in teachers a sense of ownership for their own plans for growth and for district

improvement. This information also became the basis for the next step in the project which was the individualized assessment of strengths.

Strength Assessment

The strength assessment was a critical component of the project in terms of assisting teachers with their individual plans for improvement. It would have been counterproductive to concentrate on needs that a community might not have had the resources to overcome. Conducting a strength assessment was a mechanism for focusing on organizational and community strengths to be used to reduce limitations. As Clark (3) has suggested, this process can be viewed as a matchmaking that builds on the positive traits and resources that the organization has to bring to bear on their desired task. Although rural schools possess many unique needs, they indeed also have many unique strengths. It is only when we evaluate them based on an urban model of the "one best way" (12) that rural schools are ranked second best. In reality, it has not been demonstrated that rural schools produce a less well-educated adult.

In 1959, Cyr (5) proposed that small schools were more desirable than large schools. In Big School, Small School, Barker and Gump (2) documented that small schools have a number of strengths when compared to large schools. Guthrie's (7) review of studies on school size concluded that there is evidence that the quality of school life is not always better in larger schools. Sher (11) and Nachtigal (9) have also noted the many strengths of rural education. Most of these writings deal with the enhanced individualized instruction available in small classes. As Dunne (11) points out, "Small unit size is much prized in educational circles except when applied to rural community schools" (p. 95).

The more personal contact between teachers, administrators, students and the community is also viewed as an asset. This "family atmosphere" or tight coupling of organizational parts can increase solidarity, collegiality and overall group functioning. Teachers, administrators, students and the community often are more involved and feel more responsible for school improvement in tightly knit communities.

Rural settings can be especially advantageous for science education. As Colton (4) states, "the rural environment is an open book where plants and animals, rocks and soil, sun, wind and rain are available for study and where human use of these natural resources is also evident" (pp. 1-2).

Many rural strengths can be used to reduce rural limitations. As White-Pelton (13) argues, scarce resources can even be an advantage when they result in creativity, ingenuity and innovation. Additionally, it must be remembered that what is a strength to one teacher or community may be a weakness to another. Therefore, it was essential that our strength assessments were done on an individual basis. It was also critical that teachers reviewed their aims for science education as part of the process of identifying the special attributes their rural setting had to offer for meeting those aims.

The ultimate goal of matching the positive traits or abilities identified from the strength assessment with the desired theoretical ends that resulted from the needs assessment was the third step in this project, the creation of individualized mission statements and plans for action for each teacher.

Action Planning

If we are to build a vision of the future for rural science programs, it is first necessary to develop a mission within each school/community

setting that is based upon strengths as well as needs. Critical in the development of a mission statement should be a plan of action. The concept of action planning was previously utilized in a National Science Foundation project to train elementary teachers to provide leadership at the local school level for sound science education programs throughout Oklahoma (8). In this project Action Planning was used by teachers to demonstrate how they would use the skills and knowledge they had acquired during training. An action plan is not only a product, but a process for analyzing where a teacher is in his/her teaching career and where he/she would like to be. It is a process of assessing school or district strengths and weaknesses and determining which practices should be continued and which should be changed. It is also a process of deciding what the teacher's specific role is in the change effort. Ultimately, it is a process of making some decisions about the teacher's involvement in school improvement.

One element critical to the success of any school improvement effort, and yet frequently ignored, is the plan for implementing one's vision of the future. Knowledge of the factors that affect change and a detailed plan that takes these factors, the innovation, and the organizational context into consideration is an essential component of implementation. We have the research findings to help us with the task of putting our ideals, our goals and our strategies into practice (See Fullan (6) for a complete analysis of this research). Grant participants were provided with an overview of these implementation factors and were asked to consider them as part of their plan for action. This idea was derived from components of an "Implementation Plan" Terry Astuto (1) requires as an assignment from her students in her course Strategies for Educational Change taught at Kansas State University. The concept of an "Implementation Plan" was therefore combined with the

notion of "Action Plan." These action plans became a means of incorporating participant teachers' personal mission statements with an analysis of how these missions should optimally be implemented (Appendix 1).

In developing such an action plan, the following outlined factors were considered:

1. Background and assessment of current professional assignment,
2. Organizational context,
3. Analysis of the proposed change or innovation, and
4. Implementation of the plan.

The teachers began their plans by identifying basic information about their teaching positions. This assessment of their background and current professional assignment included: (1) location and general teaching background, (2) current instructional procedures, and (3) personal assessment of teaching. A description of the teachers' images of their organization and its social structure became step 2 in the plan. This organizational content included: (1) organizational structure, (2) decision-making, (3) people, (4) influences, and (5) organizational assessment. This section of the plan provided the reader with a better understanding of the school and district as an organization. The next step in the action plan was an analysis of the proposed change or innovation. This analysis included: (1) descriptional and foundational values, (2) needs addressed and beneficiaries and priorites, and (3) practicality of the proposal. The final aspect of an action plan was to consider all factors that would enable the teachers to successfully implement their desired changes into their instructional setting. These implementation plans included: (1) factors to consider, (2) participation, (3) resources, (4) evaluation, (5) staff development, and (6) timeline of plan. (See Appendix 1 for a complete description of an action plan.)

Implementing an action plan is a process of clarification for all those involved. It is a time when participants must work out their own meaning of the proposed plan. School improvement is time-consuming, difficult, frustrating and discouraging and not everyone will indeed improve. And yet research has demonstrated that successful change is possible (6). Understanding this situation and the interrelated complexities is essential to any implementation process. Planning must be viewed as a crucial starting point and yet it must also be viewed as a tentative set of guidelines. Schools and life in general are unpredictable and rational planning is not realistic. An action plan must therefore be considered as a trial map of the future, subject to change as events change and as everyone struggles to make their own sense out of the implementation process itself. The critical effort of this project took place during the 1985/86 school year as follow-up assistance was provided to the participating rural science teachers as they attempted to implement their action plans. According to Milbrae McLaughlin (9), rural improvement efforts must provide readily available, timely, relevant, and responsive implementation assistance to be effective.

Conclusion

According to Jonathan Sher (11), a major problem with college-based rural education improvement projects is that they usually depend on theoretical conceptions which come from outside the communities served. Sher believes that "the rural community must be the basis for productive change . . . [in the schools and] changes must be tailored to the needs of the community and the region" (p. 111). This project demonstrates one mechanism available to assist rural communities with their efforts to improve their education in ways that make sense to them. This project is also an answer to Paul Nachtigal's (9) plea for a rural education reform based upon an

acceptance of rural reality. Project educators' improvement efforts reflected the unique and diverse strengths and weaknesses of their rural lives. These science teachers implemented plans that had significant meaning for them and that more appropriately matched their rural communities and schools.

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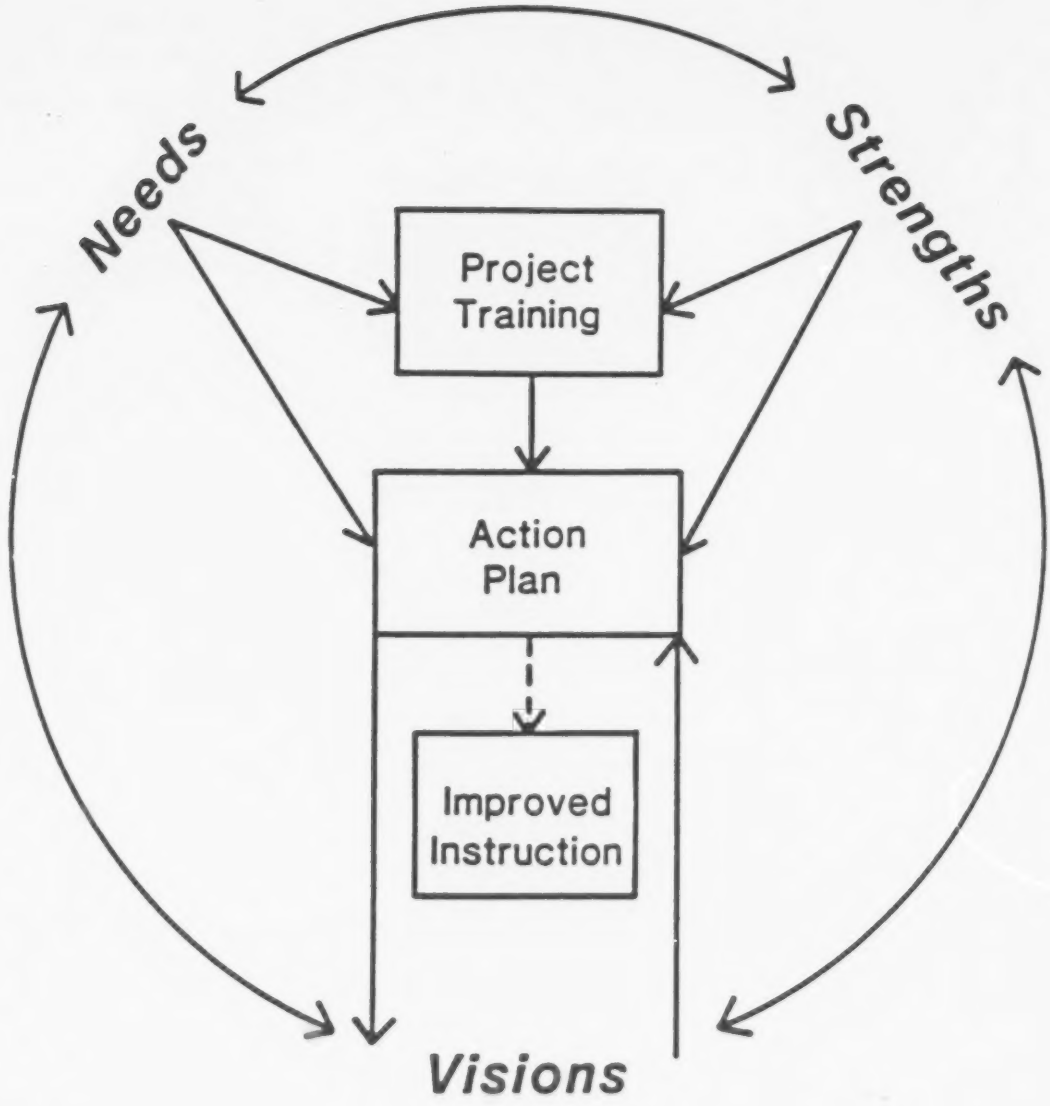
Figure 1

Conceptual Framework



A Theoretical Model for Professional Development of Rural Science Teachers

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Introduction

Staff development activities are a standardized part of school life. According to Mary Helen White Pelton (1983), staff development is a school district's key to survival in the 1980's, yet most staff development programs are ineffective in terms of their impact upon the classroom (Fullan, 1982). Providing for the continuing professional development of rural science teachers is an especially difficult task. What is needed is a transformation in our perspectives of staff development. A wealth of information is now available explaining the failures of many traditional approaches to staff development and providing a foundation for new, more effective programs. This body of information will enable each rural school to create its own model for professional development of science teachers.

Rationale

Staff development may well be one of the most critical issues in education today. According to Barbara Day, for the Association for Supervision and Curriculum Development, staff development "affects those in educational leadership positions as perhaps no other issue will" (Dillon-Peterson, 1981, pv). Mary Helen White Pelton (1983) views staff development as a school district's key to keeping pace educationally. This is an especially pertinent issue since "change and growth are endemic in our complex modern society; the school or staff which does not change and grow is destined to atrophy, to become obsolete, and to be a burden rather than a bulwark to us and to the communities we serve" (Dillon-Peterson, 1981, pv). According to Michael Fullan, "Since educational change involves learning, if any single factor is crucial to change it is professional development: (1982, p. 257). This is why staff development can be seen as a "school district's key to survival in the 1980's" (White Pelton, 1983).

In the rapidly growing science and technology field this is especially true. According to Butts and Yager, "as soon as science teachers begin their

careers, they embark upon a journey toward obsolescence" (Harty & Enochs, 1985). Gallagher and Yager, reporting the results of five surveys on the problems facing science education, cited "poor quality inservice programs and the lack of appropriate continuing education for inservice teachers" as the critical areas needing attention during the 1980's (Harty & Enochs, 1985). Voelker (1977) has cited inservice education as "the most important facet of science teacher education."

Rural science teachers face additional obstacles to keeping current with the new knowledge and techniques in their specialized fields. Most rural teachers have been required to expand their areas of specialization. Rather than concentrating on natural or physical science, or a subcomponent of one of these fields, a rural science teacher is often "the science department," and must have expertise in all fields. Because of our credentialing patterns, many of these rural science teachers begin their assignment without this broad preparation. These teachers need the opportunity to continue their professional development "in the field." The isolation of the rural schools, however, limits the growth opportunities for these teachers who may need it most. The distance between schools limits growth through collaboration, and distance from educational institutions limits growth through advanced study. Obviously rural science teachers need the opportunity for continuous professional development based on a model specifically designed for the rural setting.

Failures of Staff Development Programs

This tremendous need for professional development becomes more critical since most literature reviews of the field cite staff development as a failure (Fullan, 1979; Flanders, 1980; Howey & Joyce, 1978; Lawrence, 1974; McLaughlin & March, 1978; Rubin, 1978). According to Michael Fullan, "nothing has promised so much and has been so frustratingly wasteful as the thousands of workshops and conferences which led to no significant change in practice when

the teachers returned to their classrooms" (1982, p. 263). Hermanorwiez in his presidential address before an annual meeting of the American Association of Colleges for Teacher Education remarked that inservice education has been called a national disaster (Harty & Enochs, 1985). Flanders has called staff development the greatest spectator sport in America (McCann, 1985).

Based on a review of the staff development literature, there are a variety of reasons why staff development programs fail. Many staff development programs lack a conceptual, theoretical or research base. They are founded on the notion that teachers alone are responsible for the problems of education. They assume that assistance must come from outside the institution and must be delivered in a top down, remedial fashion. They lack sound educational pedagogy and expect teachers to learn in a fashion we would never accept for students. Basically, most staff development programs are based on a narrow perspective of the focus and formats for professional development.

What is needed is a new model for professional development. A reshaped model for all schools based on research findings and new expanded perspectives on the meaning of staff development turns out to be especially appropriate for rural schools.

Alternative Perspectives of Professional Development

A new model for staff professional development must begin with a new perspective based on the continuous developmental growth and self renewal of educators and schools for the benefit of all those involved with the system. Teachers need to be viewed as professionals involved in their own growth and capable of expanding the field of educational competence. Betty Dillon-Peterson (1981) has provided a definition of staff development that reflects this new expanded perspective.

> Staff development is a process designed to foster personal and professional growth for individuals within a respectful, supportive,

positive, organizational climate having as its ultimate aim better learning for students and continuous self-renewal for educators and schools.

Bruce Joyce (1981) has described the purposes of Staff Development in a framework that also reflects an expanded perspective of the field.

The primary task in staff development is to develop a professional, growth-oriented ecology in all schools. The purposes are three:

1. To enrich the lives of teachers and school administrators so that they continuously expand their general education, their emotional range, and their understanding of children.
2. To generate continuous efforts to improve schools. School faculties, administrators, and community members need to work together to make their schools better and acquire the knowledge and skills necessary to bring those improvements into existence.
3. To create conditions which enable professional skill development to be continuous. Every teacher and administrator needs to be a student of learning and teaching and to engage in a continuous process of experimentation with their behavior and that of their students. Each education professional needs to study alternative approaches to schooling and teaching, to select ones which will expand their capabilities and to acquire the understanding and skills necessary to make fresh alternatives a part of their ongoing repertoire of professional competence (Joyce, 1981).

These expanded perspectives provide a background for the following list of characteristics of effective staff development programs.

Characteristics of Effective Staff Development Programs

1. Professional development should be based on the interrelationship between staff development and organizational development.

School improvement is not solely the teacher's responsibility. It should be a total effort to harmonize school, subject and personal goals to meet the needs of students, teachers, the school, the district and the community. An understanding of effective organizations is needed for this effort.

2. Professional development should be based on staff and organizational strengths as well as weaknesses.

   Program planning needs to be based on multiple criteria and should be seen as a self-renewing rather than deficit process.

3. The major beneficiaries of professional development should be the student, the teacher, the school, and ultimately the community.

   Aim to create a positive climate for all those involved with the school, a school ethos that says "we are about learning."

4. Professional development must foster a personal sense of meaning for all the participants.

   Any change is a process of clarification; determining what does this mean to me. Trainers must realize that implementation will result in changes as teachers develop meaning for themselves of what the practice entails.

5. The ultimate aim of professional development should be to develop self-sufficiency of teachers and schools.

   Strive for self-improvement and "ownership" of individual growth. Outside funds and consultants can provide a needed upfront "boost", but internal strengths in the form of peer assistance and inside consultants will keep a program going. Therefore, programs should have a problem solving emphasis while aiming to develop and strengthen a school's ability to analyze their own needs, plan to meet those needs and implement and evaluate their plans.

6. Professional development must be continuous and developmental in nature. Hit and run training doesn't work! Needs change and assistance must strive to be specifically geared toward those needs. This means that help must be ongoing, especially during implementation when the needs are the greatest.

7. Decisions concerning professional development must be shared by all recipients or participants of the program.
This creates a sense of "ownership" and personal meaning needed for change. It also builds a sense of unity and "mission" for school improvement. It is based on the concept of a self-renewing heterarchy rather than a top-down deficit model.

8. Professional development must reflect adult learning characteristics. Adults learn in a variety of ways and this should be reflected in a wide variety of program approaches, such as formal, informal, one to one and independent. Adults also value meaningful, non-threatening, respectful, supportive environments. Trainers should treat teachers as professionals, building on their sense of efficacy and utilizing their existing strengths.

9. Professional development should be viewed as "practical" according to Doyle and Ponders' "practicality ethic" (1977).
The program participants must view the innovation as practical in terms of its quality, value and need as well as its manageability in terms of fitting their teaching styles, abilities and philosophical principles. The teachers must ultimately decide "this program is worth its effort" or the innovation will probably not be implemented.

10. Professional development needs to include means to motivate the authentic participation of teachers. Motivational factors include: improving teachers' competence, success and advancement; increasing their opportunity, sense of autonomy, and participation in decision making;

improving conditions in the school; as well as the more conventional use of monetary reimbursement and release time (McCann, 1985).

11. Professional development must be based on sound theory and research findings.

This applies to the staff development approach as well as its content. Research associated with effective instruction and effective schools, as well as methods and content in subject areas should provide a basis of program content. In addition certain issues such as multicultural and sex equity education and other socially pertinent issues should be a part of the theoretical foundation of preparing teachers for today's changing educational world.

12. Professional development must receive strong administrative support.

Teachers don't take programs seriously if administrators don't. Administrative support includes personal involvement, providing release time, resources and encouragement. Administrators are the gatekeepers of change and must be supportive for any significant school or district-wide change to occur.

13. Professional development must be carried out in a variety of divergent approaches.

Programs need to expand from the lecture-discussion-workshop format into advanced professional study, self-directed, personalized, collaborative and/or staff-school development options. Action research, child study cases, or theory development should all be staff development possibilities (McCann, 1985).

14. Professional development programs should encourage diversity and experimentation in the schools.

Educators need to stimulate growth in their relatively low technology field (Clark, 1981). Effective schools are not stagnant, but places of action where individuals feel free to try innovative approaches. The

diversification of teaching approaches, teaching roles and role relationships should all be encouraged.

15. The evaluation of professional development programs should be ongoing and multidimensional.

    Formative evaluation alters and improves practice. Program evaluation should be related to changes in teacher beliefs and behaviors and in some ways to student outcomes. But more importantly success should be measured by the extent it maximizes participation, takes advantage of staff strengths and the number of proactive alternative processes invented or adaptations made to meet individual, school and community needs. In essence the extent to which participants have increased their capacity to function in the system (Clark, 1981).

16. Professional Development plans should ve viewed as a "road map" for a shared vision of the future.

    Planning can be the key to success or failure of new programs. Planning must be viewed as a crucial starting point and yet it must also be viewed as a tentative set of guidelines. Schools are too complex and unpredictable for rigid national planning to be realistic. Plans must be considered as a trial map of the future, subject to change as events change and as everyone struggles to make their own sense out of the proposed innovation.

Examples of Effective Rural Staff Development Programs

All of the previously described characteristics of effective staff development are especially well suited to rural schools. The following examples of rural staff development programs have been collected and explained by White-Pelton (1983) in Staff Development in Small and Rural School Districts. They provide many examples of situations in which personal and professional development to enhance both teachers and the organization are tailored to meet the unique needs of the rural setting.

Individualized Staff Development Programs

Teachers Write Their Own IEP - Dist. 54, Skowhegan, Maine

"Improve Your School Program and Earn Credits"
- Madonna College, Michigan

Locally Developed Recertification Plans
- Union 98, Mount Desert Island, Maine

Peer Teaching

N.S. F. Honors Program

District Team Training - Hastings-on-Hudson, New York

Local Communication Leaders - District 54, Maine

Cooperation Among Districts

Clustering for Rural School Improvement
- McRel's Rural Education Project

Southeastern Colorado's Educational Renewal Center

Nebraska's Project Innovative Curriculum (PIC)

Technological Staff Development Programs

Telephone - Kansas Continuing Education Network - TELENET

Satellite - Appalachian Education Satellite Project

Radio - Alaskan National Education Association

Mobile Van - Pennsylvania State University

Mobile Teaching Unit - University of Iowa Center for Educational Experimentation, Development and Evaluation

State Department Programs

Vermont's Resource Agent Program Workshops

Maryland Professional Development Academy

Maine Comprehensive System of Personnel Development

Illinois Extended Year Program

Conclusion

Professional development implies growth and self-actualization for the individual and the organization. This self-renewing process requires change in what schools and teachers think and in what they do. Change is time-consuming, difficult, frustrating and discouraging and not everyone will need change. And yet research has demonstrated that successful change is possible. Understanding this situation and the many interrelated complexities is essential to any staff development process. Planners must never lose sight of the fact that:

> "Our primary value concerns our need to help ourselves change and learn, for us to feel that we are growing in our understanding of where we have been, where we are, and what we are about, and that we are enjoying what we are doing . . . To help others change without this being preceded and accompanied by an exquisite awareness of the process in ourselves is delivering a product or service which truly has little or no significance
> for our personal or intellectual growth" (Sarason, 1972, p. 122).

Rural schools need to create visions of new possibilities for the professional development of their organization. These visions must be based on the unique needs and circumstances surrounding each school. The process of personal and organizational growth can be enhanced for rural schools by allowing the needed time, support, and resources and by utilizing new perspectives of professional development and by considering the research base on characteristics of effective staff development programs. Together this body of knowledge will enable each organization to create its own model for professional development of rural science teachers.

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Understandings and Misunderstandings of Biological Concepts of Students Attending Small High Schools

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Understandings and Misunderstandings of Biological Concepts of Students Attending Small High Schools

Science educators need to be concerned with methods used to evaluate science concept understanding of students enrolled in science courses. Chapter tests using recall questions given periodically throughout the course of study are taken as adequate evaluation for concept understanding. Many recent studies show that the understandings of many scientific concepts developed by students completing high school science classes are naive compared to understandings held by scientists (Wandersee, 1984; Kuethe, 1963). College students have also been shown to exhibit specific misunderstandings of scientific concepts (Novak & Nussbaum, 1976). These findings challenge the concept that as a child progresses through school and interacts with knowledge presented verbally, he/she will eventually gain a better understanding of the concepts to be learned.

Shepherd and Renner (1982) state that schools are predicated upon the assumption that the longer students stay in them and study content, the more understandings about the content taught the students will develop. If so, then 12th graders should have better understandings of the content taught in schools than 10th graders. Shepherd and Renner revealed that in some instances the number of misunderstandings of the phenomenon of lake reversal due to temperature change was higher in 12th-grade students than in 10th-grade students used in the study.

Current educational strategies alone may not be the cause for misunderstandings demonstrated by students on science concepts. Naive explanations passed on to children by adults with misunderstandings of science concepts may also contribute to concept misunderstandings. Wandersee (1984) suggests that students living in areas where cultural endeavors are influenced by scientific research could develop better science concept understandings than students living in rural areas. Highly populated urban areas are more likely to attract

industries and professional workers that use current science and technological research whereas rural areas attract few people involved in careers in science.

Comparing schools according to student population, location, and socioeconomic status of students who attend them has been a topic of previous research (Lehman, Kahle, & Nordland, 1981; Peshkin, 1978; Simpson & Marek, 1985). These studies did not examine the issue pertaining to the discrepancies in understanding biological concepts that may exist between students attending large schools and students attending small schools. The purpose of this research is to ascertain if students from small schools show fewer understandings and more misunderstandings of specific biology concepts than students attending large schools. The biological concepts to be used in this study are: diffusion, homeostasis, classification of plants and animals, food production in plants, and the cell.

Research showing differences in cognitive development between students attending small schools and students attending large schools could be important to understanding science concepts. Many psychologists and science educators indicate that concept understanding is related to the student's cognitive developmental level (Raven, 1972; Robertson & Richardson, 1975; Tamir, Gal-Choppin, & Nussinovitz, 1981; Shepherd & Renner, 1982; Lawson & Renner, 1975; Piaget, 1970). Furthermore, students attending small schools are not as intellectually developed as students attending large schools (Renner et al., 1976; Simpson & Marek, 1985). Therefore, it can be hypothesized that students in small schools will be less capable of developing understandings of science concepts.

This hypothesis could be tested with concepts requiring formal thought. Renner (1985) states that students reasoning at concrete operations modify sensory input to fit into their mental structures which are not yet capable of formal thought and that this could lead to misunderstandings developed about a formal concept. Therefore, instances of misunderstandings should be more

prevalent among small school students on formal concepts because concrete operations are more prevalent among small school students.

It is problematic whether or not large schools provide better instruction than small schools (Hill, 1984; Williams, 1983). If large schools do offer superior instruction, then large school students would also be expected to develop better understandings of concrete concepts that require only concrete operations.

Since students in large schools are more intellectually developed and are thought to receive better instruction, the following hypothesis can be formulated: Students attending small schools show less instances of understandings and more instances of specific misunderstandings of the concepts of diffusion, homeostasis, classification of plants and animals, food production in plants, and the cell.

Experimental Design

The investigator was granted permission by administrators of seven high schools to evaluate biology concept understandings and misunderstandings of 10th-grade students attending those high schools. These schools were located in a rural section of Southwest Oklahoma. Four of the schools had total enrollments in grades 10 through 12 of less than 150 students in each school. Three of the seven schools had total enrollments in grades 10 through 12 exceeding 900 students per school. The schools used in this study with enrollment less than 150 students per school are identified as small schools. The schools with enrollment exceeding 900 students per school are identified as large schools.

Sixty-seven 10th-grade students from four biology classes in small high schools and 75 10th-grade students from four biology classes in large high schools composed the population for this study. All schools of this study were located in rural areas where agriculture is the predominant industry. The socioeconomic backgrounds of the students from all schools were similar

with the majority coming from white, lower- to middle-class families; a small percentage of students were black and hispanic.

The understandings and misunderstandings were measured with Concept Evaluation Statements (CESs). These statements described situations and asked students to use biological concepts in answering questions about each situation. For example, the students were asked in one CES to explain why a container of water eventually turned light blue when a drop of blue dye was dropped on the surface of the water. An answer demonstrating sound understanding of this statement would have completely explained the process of diffusion.

One hundred completed CESs were randomly selected--50 from the small schools and 50 from the large schools--for use in this investigation. Average age of the students in the random sample from the small school was 15.8 years. The average age for the students in the random sample from the large school was 16.1 years.

Through interviews with teachers of the eight biology classes used in this study, the following information was obtained: All classes spent no more than one day a week involving laboratory activities, the teachers used exposition or formal teaching methods (Schneider & Renner, 1980) to present concepts to the students in their classes, all classes had been exposed to all five concepts used in this study, the classes were not honors or remedial classes, and each class used the same textbook--Modern Biology (Otto, Towle, & Madnick, 1983).

Each Concept Evaluation Statement (CES) described one of the five biological concepts; diffusion, homeostasis, classification of animals and plants, food production in plants, or the cell. Three of the statements--the classification statement, the food production in plants statement, and the homeostasis statement--were written by the investigator and content validated by a panel of science educators. The panel of science educators included:

two professors of science education, one professor of botany, and three high school biology teachers. Two of the CESs, diffusion and the cell, were developed and validated by Marek (1986).

The CESs did not have the concept named in the statements. Each CES described a concept and it was the student's responsibility to identify and explain the concept. Each CES had a readability level of seventh to eighth grade.

From responses written on the CESs by students from the small and large school samples, the level of understanding of each concept was determined. For this investigation five levels of understanding were identified: sound understanding, partial understanding, partial understanding with misunderstanding, complete misunderstanding, and no response. Those categories are similar to the categories used in other research (Cate, 1981; Shepherd & Renner, 1982; Marek, 1986). The responses each student gave to each concept statement were evaluated by the investigator and classified in one of the five levels of understanding. An explanation of the categories and how responses to each statement were classified into those categories follows:

Sound understanding. From information obtained from biological texts (Vander, Sherman, & Luciano, 1980; Weinberg & Kalish, 1977) the investigator developed valid responses for each concept statement which represented sound understanding of that concept. Responses showing sound understanding of the CESs had to contain all elements emphasized in the validated response for that particular statement. In other words, for a response to demonstrate sound understanding of the diffusion concept, the response had to contain all elements of the validated response developed for the diffusion statement. This is also true for responses given to the other four concept statements.

Partial understanding. Responses demonstrating partial understanding of the concept were characterized by the student mentioning at least one but not all of the elements in the validated response.

Partial understanding with misunderstanding. These responses showed some understanding of the concept but also made a statement which demonstrated a misunderstanding of part of the concept. The response could possibly mention all of the elements of the validated response but also contained information which demonstrated a misunderstanding of the concept being evaluated.

Complete misunderstanding. None of the elements of the validated response for sound understanding was demonstrated. An attempt to explain the concept described in the concept statement was made. However, these explanations were misunderstandings, not understandings held by scientists or stated in science texts.

No response. These responses were characterized by one of the following: The student simply restated the question; the student gave an irrelevant answer to the statement; the student replied, "I don't know"; or no response was given to the statement.

Pearson chi-square analysis was used to determine if discrepancies between the large school sample and small school sample for the number of students showing each level of understanding were significant. This was done for each concept of the CESs. Chi-square analysis was chosen as the statistical method used in this investigation because the data from the large school sample and small school sample did not produce calculated means. The data collected from this investigation consisted only of the number of responses placed in categories representing levels of understanding. The chi-square calculation is dependent upon the number of the responses considered to represent each level of understanding from two independent samples--students from small schools and students from large schools. Small differences between the small and large school samples at each level of understanding produce small chi-square values which may not exceed critical values. This indicates no significant dependence for the level of understanding and the independent variable. Larger differences between the two samples for the number of

responses at each level produce larger chi-square values which may exceed critical values, demonstrating a dependence between the two samples for the independent variable.

Since the small school and large school samples consisted of only 50 completed CESs each, it was determined that type II errors would be more probable than type I errors. Using alpha levels as low as .01 would increase the likelihood of making a type II error. Because of this the level of significance for this investigation was set at = .05.

Results

Fifty student-responses from small schools and 50 student-responses from large schools were compared with respect to the level of understanding of five biology concepts: diffusion, homeostasis, classification of plants and animals, food production in plants, and the cell. Responses were classified as representing sound understanding, partial understanding, partial understanding with misunderstanding, a complete misunderstanding, or no response. The responses to each concept statement were evaluated to determine if students from large schools develop better understandings of the research concepts than students from small schools.

The numbers of students from the small and large school samples demonstrating each level of understanding for the diffusion statement are found in Table 1. A bar graph of these data is found in Figure 1.

Responses given to the homeostasis statement of the small school sample and the large school sample were evaluated and categorized. The numbers of responses demonstrating each level of understanding from the large and small school samples are included in Table 2 and Figure 2.

Responses given by students from the large and small school samples to the classification statement were evaluated and placed in one of the categories previously mentioned. Table 3 and Figure 3 contain data showing the

levels of understanding of students from the large school and small school samples for the classification statement.

Responses given by students from the small and large school samples to the food production in plants statement were evaluated and classified according to level of understanding. Table 4 and Figure 4 demonstrate the differences found between the large and small school samples for the food production in plants statement.

Responses given to the cell statement by the students from the large and small school samples were evaluated and placed into one of the five levels of understanding. Table 5 and Figure 5 show discrepancies found for each level of understanding between the large and small school samples.

Table 6 contains chi-square calculations from the contingency tables prescribed in Tables 1 through 5. These calculations demonstrate that the discrepancies found between the large and small school samples were significant at the .05 level of confidence for the diffusion and homeostasis statement. The differences observed between the large and small school samples for the classification, food production in plants and cell statements were not significant at = .05.

Discussion

The discrepancies between the large and small school samples for number of students at each level of understanding are significant ($p < .05$) for only the concepts of diffusion and homeostasis. The chi-square calculations for the contingency tables illustrating discrepancies between large and small school students for the concepts of classification, food production in plants, and the cell are not significant ($p > .05$). Based upon these chi-square calculations, a relationship exists between the degree of understanding students develop to certain biology concepts--diffusion and homeostasis--and the size of school the students attend. Graphs (Figures 1 and 2) demonstrate that students attending large high schools develop more instances of under-

standing the concepts of diffusion and homeostasis while students attending small high schools show more instances of misunderstandings or no understanding of diffusion and homeostasis. This relationship, however, cannot be drawn for school size and concept understanding for the concepts of classification, food production in plants, and the cell because the chi-square calculation did not exceed critical values at = .05.

The intellectual developmental level of a student can affect how thoroughly a student understands a concept (Shepherd & Renner, 1982; Raven, 1972; Robertson & Richardson, 1975). Also, concepts taught above the developmental stage at which a student is capable of functioning could lead to misunderstandings about that concept (Renner, 1985). A greater percentage of students in larger schools function at formal operations as compared to students in small schools. To better understand the results of this investigation, the nature of the concepts utilized in this investigation is presented.

Renner (1985) and Lawson and Renner (1975) have demonstrated that concepts taught must be matched to the developmental level of the learner before the student will understand what is taught. Lawson and Renner state that "concrete thinkers only learn concrete concepts while formal thinkers learn both formal and concrete concepts."

Formal concepts are those concepts that can only be understood from a "position within a postulatory-deductive system" (Renner, 1985). To understand a formal concept, the students must be able to perform mental operations on models, postulates, and verbal propositions. The student using formal thought can look at all aspects of the concept at one time and tie all of the aspects of the concept together into a "structured whole" (Brainherd, 1978; Muuss, 1982).

Concrete concepts are those that can be understood only through direct experience with objects, events or situations which produced data from which the concept can be formed. Concrete learners are capable of understanding

concrete concepts. Concrete thinkers are not yet capable of performing operations on verbal propositions, postulates, or hypotheses. They are not capable of dealing with possibilities beyond what they can directly experience. Also, concrete students are only capable of dealing with one aspect of a concept at one time (Muuss, 1982).

Of the concepts evaluated in this investigation at least three require the use of formal thought to develop sound understandings. These concepts are: diffusion, homeostasis, and food production in plants.

To demonstrate sound understanding of the statement which describes the concept of diffusion the students must be able to construct the following mental models:

1. Molecules that compose matter are constantly in a state of random movement which causes the blue dye molecules to move throughout the water, and

2. the resulting mixture contains blue dye molecules evenly dispersed among the molecules of water as a result of the random movement.

These two postulates are required before sound understanding can be expressed. Since each idea represents postulates and cannot be directly experienced, sound understanding of diffusion requires the use of formal thought.

Concrete learners could show some understanding to the diffusion statement. Responses such as "the blue dye spreads from greater amounts to lesser amounts until the water in the container is light blue," and "the dye molecules move into the container of water and turn the water slightly blue" represent partial understandings of the diffusion concept. These responses could be given by students using concrete operations because students can directly observe the dye moving until a uniform light blue liquid results. Students giving this type of answer are not demonstrating any mechanisms--the random movement of molecules--to explain why the blue dye molecules move from areas of greater to lesser concentration. They have built and interpreted a

mental model through direct experience. Also, no mention is made of the dye molecules being evenly distributed throughout the solution in the resulting mixture--that understanding also requires formal operations.

Formal thought is required for students to be able to understand the concept of homeostasis. To show sound understanding of the homeostasis statement, the student must have been able to construct the following mental models:

1. Oxygen is carried to the body by the circulations of blood and enters the body tissue in the capillaries;

2. oxygen is used by body cells and produces energy through the process of cellular respiration which allows the body muscles to work during exercise;

3. chemical reactions occurring in the muscle cells produce energy and cause heat to build up in the body;

4. as sweat evaporates from the skin, heat is drawn from a person's body; and

5. neurological receptors in certain areas of the body and centers in the brain can detect changes and cause appropriate responses to these changes.

To demonstrate sound understanding of the homeostasis statement a student must understand the mental models described. Also the student must be able to understand the body functions and how changes in these functions affect one another. The student must be able to identify all changes occurring in the internal environment of the patient in the homeostasis statement and combine these changes into the idea that the body can maintain a level of internal constancy. In other words, the student must understand why the changes occurred in each body function and be able to understand the effects of returning one variable of the body's internal environment to equilibrium. The student must be able to understand multiple causes and effects and construct the idea that the body can maintain "dynamic equilibrium" (Piaget, 1970). Understanding the concept of homeostasis can be compared to the logic that

Cate (1981) described as necessary to understand evolution. The mental ability to make a generalized statement from specific ideas is known as scientific inductive responding which is a characteristic of formal thought (Brainherd, 1978).

Even partial understanding of the homeostasis concept requires the use of formal operations. Producing energy through respiration, evaporative cooling and oxygen-carbon dioxide exchange in the capillaries are examples of physiological processes that require the use of mental model building and reasoning based upon assumptions to understanding. The following responses represent partial understanding but also the use of formal reasoning:

1. "The body's respiration rate increased to supply more oxygen to the muscles for energy; due to the production of heat the body began sweating to cool it down."

2. "The person sweats because when sweat evaporates, the heat is drawn from the body causing it to cool down."

Sound understanding of the concept of food production in plants requires formal operations because water cannot be directly observed as a variable in the food making process. A student must also be able to separate and control variables to understand that water, carbon dioxide, light and chlorophyll must be present before a plant can produce food. Separation and control of variables is a characteristic of formal thought.

The fact that carbon dioxide, light, and chlorophyll contribute to the food making process can be demonstrated by growing plants in the absence of carbon dioxide and chlorophyll and testing for the presence of starch in the plant's leaves. The use of variegated leaves, such as the coleus leaf, which lack chlorophyll in some areas, can demonstrate a lack of starch production in these areas. Understanding that carbon dioxide, light, and chlorophyll are part of the food making process and that soil is not taken in by the plant can be understood by observations and measurements of plants and the soil those

plants are grown in. Therefore, partial understanding of the production statement could be demonstrated by students using concrete thought.

It should be noted that the concept tested here was that plants use carbon dioxide and water in the presence of sunlight and chlorophyll to produce food and that soil is not used in the photosynthetic process. This question did not attempt to measure the students' understanding of the models of the light and dark reactions.

The classification statement can be understood from the manipulation of concrete objects; therefore, only concrete operations are required for sound understanding of the classification concept. Muuss (1982) states that being able to classify objects and understand the characteristics from which they are classified is a characteristic of concrete thought. Also all observable characteristics which can be used to describe the specimen referred to in the classification statement can be directly observed through direct experiences such as laboratory activities. Microscopic analysis of animal and plant cells will reveal cellular differences between animals and plants. Also direct observation of different animal and plant specimens will demonstrate responsiveness and movement which are attributed to some animals.

The concept that the basic units which compose living things are cells represents a concrete concept. The living specimens described in the cells statement can be observed microscopically to identify the units known as cells. From observations made of the nonliving materials described, one could easily tell that these are not living because of the absence of responsiveness, reproduction, growth, and other characteristics which occur in living things. Also microscopic observations would verify that the nonliving objects do not have the basic units called cells that living specimens have.

Since cells and some characteristics of life can be demonstrated through direct observations of living specimens, the concept tested for by the cell

statement represents a concrete concept. Students using concrete operations would therefore be able to demonstrate sound understanding of the cell concept.

Recommendations for Further Research

A problem exists for small schools regarding the cognitive developmental level of their students. The students of this study in the small schools were hindered in their ability to understand concepts that require formal thought. Research in small school education is needed to find ways to enhance cognitive development among students who attend these schools. Variables that exist in large schools that allow increases in cognitive development to occur need to be isolated so measures can be taken by administrators and teachers in small schools that will increase intellectual development.

Science teachers in small school districts need to be aware that their students are not as intellectually developed as students in large schools and measures should be taken to implement proper curricula based upon the developmental level of the learner. It is quite possible that students in small schools will need special instruction that enhances intellectual development. If current teaching strategies are maintained in small schools, students attending these schools will continue to develop misunderstandings of some biological concepts without making any gains in intellectual development.

Consideration is needed for other concepts where differences in concept development may exist between students from small schools and students from large schools. Concepts pertaining to ecology, the DNA molecule, digestion, reproduction, respiration, and genetics are examples of concepts where differences may exist between students of small and large schools in regard to concept understanding.

When the responses given by all students from both the large and small school samples are combined, those data suggest that the lack of concept understanding is not only a small school problem but a problem within science education at all schools regardless of student enrollment size. It should be

noted that no student demonstrated sound understanding of the homeostasis concept. Also over 50% of all students from both samples gave no response to the cell statement. It is possible, since the cell statement was the final statement in the CES form, many students may have opted not to respond because of fatigue and/or lack of cooperation in participating in the investigation. This should be investigated further.

Cate (1981) conducted an investigation into the concept of evolution and determined the concept to be inappropriate for 10th-grade biology instruction. Studies such as this are needed for other highly formal concepts, such as homeostasis, so that curriculum developers can determine if these concepts are also inappropriate for 10th-grade biology courses.

Teaching procedures may also contribute to concept misunderstandings. The use of concrete instruction or the Learning Cycle has been effective in increasing cognitive development, IQ, and science achievement scores (Purser & Renner, 1983; Atkin & Karplus, 1962; Schneider & Renner, 1980; Marek & Renner, 1979). No research has been undertaken to ascertain if concrete instruction can prevent misunderstandings or increase understandings of science concepts. Piaget (1980) writes that teaching concepts through formal, verbal presentations requires students to use formal thought to understand the concept. This view is echoed by Lawson and Renner (1975). It was noted earlier that the classes from which the samples were selected were taught through formal procedures and spent less than one day a week engaging in laboratory activities. Concrete learners can develop understandings to concepts only by direct experiences such as manipulating those objects which are pertinent to the concept. Classes from which the students were selected were not allowing students to develop understandings of the concepts through direct experience. The lack of direct observations of cells and characteristics of plants and animals could be the reason why high instances of misunderstandings and no

understandings were developed by students from both the large and small school samples.

Finally, science educators need to be concerned with long-term effects of developing misunderstandings. In other words, if a student develops a misunderstanding early in his/her education, how difficult is it to correct that misunderstanding? If misunderstandings are developed in 10th-grade biology classes, are these misconceptions held by that student after further instruction about these biology concepts? It is possible that teaching concepts to students who function at levels of intellectual development which do not permit them to understand those concepts would have an effect upon that student's achievement in advanced high school and college biology courses. If this is so, science educators must become aware of the fact that science curricula must match the developmental level of the learner. Also the teaching of appropriate concepts must be taught where students are allowed to develop sound understandings of the concepts. It is the recommendation of this investigator that studies be performed with concrete instructional methods to determine if instances of misconceptions can be reduced and replaced with sound understandings.

Summary

Students attending large schools develop more instances of understandings and less instances of misunderstandings of biological concepts than their small school counterparts for the concepts of homeostasis and diffusion. These differences are due to a higher percentage of students in large schools capable of formal operations; sound understandings of diffusion and homeostasis require students to use formal operations.

Formal operations are required for sound understanding of food production in plants. The results of this research did not fit into the model that larger school students are more intellectually developed than smaller school students. The milieu in which the students from small schools live may

provide sufficient experience with this concept to prevent some instances of misunderstandings and allow at least partial understanding of the food production in plants.

Differences observed between students attending large schools and students attending small schools for concept understanding can be attributed to differences in intellectual development. Small school science teachers must be aware of this and provide experiences that will increase cognitive development in students that attend smaller schools. One solution is to use inquiry based teaching methods--e.g., the learning cycle--in science classes taught at all levels. The use of the learning cycle could provide the experience necessary to remedy the problem science teachers now face regarding how well students understand science concepts.

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The Local Environment Becomes A Learning Experience

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The Local Environment Becomes a Learning Experience

An outdoor area is a resource that is available to almost all schools regardless of size, location, budget or geographic location. Having a local area available for long-term study (a site not more than a fifteen-minute walk from the school) provides the teacher with an almost limitless set of possibilities for children's learning.

Through working with both elementary children and preservice teachers, the following set of starter activities was developed to ease the process of starting to use out-of-doors study areas. It should be remembered that these suggestions are starters to be used, modified, or rejected on the basis of what is available locally, curricular suggestions, and the needs and interests of the particular set of children involved. They may also be supported and supplemented by use of such models and the Science Curriculum Improvement Study and other appropriate resources.

Once you have selected a safe and appropriate site and obtained permission to use it, review science resources, teachers' guides, and journal articles for possible outdoor activities. The following activities are organized according to time required rather than grade level. Short range activities can be completed in one or two visits. All activities can be adapted to a particular site or to the needs of specific students.

Collecting Trash

Defined as anything that man has deposited in the selected study area, trash can provide very useful learning experiences. In our study area children can sort it into categories that they have discussed and agreed upon. When this is done, there are a variety of learning activities to choose from, depending on the level and interests of the children involved. These could include the following:

*To learn the basics of graphing with live data, young children create a circle graph by arranging categories of trash in a circle, on the floor or playground, and separating the categories with tape or string.

*At a more sophisticated level, the categories of material may be weighed and the weights recorded in graphic form.

*Collected trash may be sorted into materials that are in their natural state, such as wood, or processed items

*The collector can provide children with a basis for investigating what is able to be recycled and how these processes are carried out.

*Another investigation would be to try to determine the length of time various categories of material would take to biodegrade completely. This exploration will produce a wide range of times for items from paper tissue to aluminum cans.

Almost endless adaptations of investigations to be undertaken exist. For example, a child who found a piece of violet glass and was fascinated by it found an antique dealer who estimated that the glass had been on the ground for over eighty years.

Collection of such items as rocks, soils, or plant samples may be made in an outdoor study area. Within limitations children can select sets of materials for later examination, more careful study, or sorting activities. For example, leaves can be collected and used with pupils with a wide range of sophistication and understanding. Very young children may start with sorting by obvious color or size where older pupils may sort by veining, complexity, or other criteria that they may identify.

Children should be encouraged to attempt to sort collected material by criteria other than visual. Sorting leaves may be based on how the surfaces feel to the child who has closed his or her eyes. Samples of small rocks can be sorted by feel and by how they sound when dropped on a metal plate, as well

as in more conventional ways. Small samples of a variety of vegetation may be collected.

Although it will vary from site to site, an outdoor area provides a wide range of opportunities for the study of living things. A study of animals might well include a specific effort to find evidence of animal feeding areas. Small animals such as rabbits, ground squirrels, and field mice often leave evidence of feeding, food gathering, or homes. Have children record evidences of animal activity and look for current activity without disturbing the homes of the animals. A similar study may be carried out in finding both insects and evidence of their activity. Children may collect insects that can be successfully maintained in the classroom for long-term detailed observation. (Note: In order to feed an insect successfully, the collector should determine what it has been feeding on at the time of collection.)

Another type of study is to make an inventory with description and either drawings or samples of all of the living things observed in a selected observation. This area may be a very small one selected by an individual pupil or a fairly large one studied by a group of the whole class.

A very interesting late summer or fall activity is to make a collection of seeds growing in the study area and attempt to determine the means by which seeds are distributed. One way of recording this information is to use the actual seeds, pictured with the means by which they are transported, to make up a bulletin board. Children were surprised to find that they themselves were among the ways that seeds were transported as they pulled burrs from clothing after returning from the study area. In addition, children identified animals carrying burrs and sticky seeds and others carrying seeds and nuts to use for food. Other means studied were windborne seeds, fruits that were carried by birds, and pods that popped open to scatter seeds in the area. Tumble weeds were reexamined as a device where the whole plant moved to spread its seed as it went along.

Observing Prickly Pear Cactus

1. These two observations of plant adaptation provided both short- and long-term observation of a single plant.

The prickly pear adaptation that children observed on a short-term basis was the ability of the plant to rapidly secure and store relatively large quantities of water.

In exploring this, children examined two adaptations. First, the dry top cover was gently removed in an area on one side of a mature prickly pear to expose some of the root system. This was easy to do since the roots are close to the surface and widespread, a virtual mat around the plant. From this the children developed an understanding of the probable area of roots around other plants and that a very small amount of rainfall would soak down to the roots lying close to the surface.

Second, another prickly pear was selected for observation of its ability to take up moisture. Children observed the general appearance of the plant and the wrinkled surface of its leaves. They measured the thickness of the middles of the large leaves and cut a small slice from a leaf so that the interior could be examined. Next, the area around the plant was soaked with water that the children had brought until a small test hole showed that the soil was wet for several inches below the surface.

At the next observation, two days later, the children again examined the appearance of the plant, looked at another slice of leaf, and remeasured the center thickness of previously measured leaves. Children were impressed with both the changed appearance of the whole plant as well as with the juicy slice of leaf as compared to the withered slice taken before watering. The measured leaves were appreciably thicker.

The whole experience helped the children to understand how a cactus is equipped for the rapid collection and storage of water.

2. The long-term observation involved occasional watering of the same plant throughout the growing season to see if there would be a difference between watered and unwatered plants. Since the season was unusually dry, a marked difference appeared. The unwatered plants flowered in the same way as the watered plant but, as they grew drier, shed their flowers and did not produce fruit, while the watered plant produced fruit that contained seeds.

Measuring Individual Plant Growth

This activity may be carried out in a variety of ways that will provide a profitable learning experience for children.

1. Annual plants should be measured during periods of rapid growth. One way that older children carried this out and kept a record was to sketch the plant on first measurement and to have the sketch accurate regarding the height and width of the plant: Successive measurements were recorded by using different colored crayons and sketching over the original so that there was a visual image of growth over weekly or longer observation periods.

2. Another observation strategy on bushes or trees is for children to measure new growth on various plants, record the information, and compare new growth rates of various plants.

3. On a long-term basis, children may observe growth and change from the time that a plant flowers until the seeds start to mature.

Long-term studies will help develop an understanding of the seasonal impact on warm-blooded animals such as birds in the study area. Monthly observations that are recorded will help to develop an understanding of the effect of the seasons on visible populations. The children can also develop questions about how animals adapt to seasonal changes and about where the animals may be when they are not visible.

Studying Insects

In a similar manner, it is possible in many study areas to identify a particular insect or variety of insects such as grasshoppers or caterpillars

on a particular type of plant. One can perform systematic observations of the size of the insects as they grow and undergo changes such as the formation of wings, shedding of skin, or spinning of a cocoon.

An ant hill will provide an excellent opportunity for a study of the range of ants from the hill, the sorts of natural food that they carry away, and how they proceed to defend their home if disturbed.

Outdoor study areas are a rich and varied resource that is available to schools in all sorts of areas and to pupils of all ages. Use of these areas can assist in acquainting the child with its environment on a firsthand basis. In addition to the direct learning that takes place from this experience, the child develops a personal background and base of information that will allow him or her to compare this environment with descriptions of other environments and thus have a better understanding of them. Experience and practice in observing, collecting, organizing, examining and recordkeeping provide tools for approaching problems in a less familiar setting. These experiences offer both teachers and children opportunities for a better understanding and appreciation of both the area in which they live and of the tools used by scientists to study an area.

Report of the Findings of A Needs Sensing Conference for Rural Science Educators

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1985

OVERVIEW

The Needs Sensing Conference brought together KSU faculty and administrators, public school teachers and administrators, and individuals from non-formal settings, for the purpose of: (a) exploring ways for improving precollege science education and environmental education in Kansas, particularly in the rural and small school areas; and (b) reviewing and validating the proposed plan for a KSU campus-wide Center for Science Education. The Conference participants developed recommendations for each of four educational levels: elementary school, middle school, senior high school, and environmental/non-formal education. Each group produced a consensus set of views on science education needs at its level and a list of strategies for meeting those needs. The four groups agreed that a KSU campus-wide Center for Science Education would provide the most beneficial framework for implementing the recommended strategies. In addition to the group reports, each of the four science education resource consultants formulated their own report on the Conference outcomes. The resource consultants were also united in agreement on the need for a Science Education Center and its benefits to each educational level addressed.

The four groups envisioned the Science Education Center as a source of research findings to support program development, as a clearinghouse for resource materials and as a program site for in-service training and science curriculum development. Other potential functions frequently cited included coordinating activities with local industry and business including a speakers bureau to provide speakers on topics such as science careers and science-technology-society issues; providing training in the use of hands-on science activities; and increasing teaching skills related to planning, preparing objectives, and evaluating student progress. The Science Education Center was also discussed as an agency for providing leadership to improve the

content background of practicing science teachers and environmental educators, to recommend policy for state-mandated requirements for the pre-service and in-service education of precollege science teachers, and to develop innovative programs to prepare new science teachers for the field.

INTRODUCTION

Kansas State University has a strong tradition of quality precollege science teacher preparation; a commitment that is directly tied to the land grant University mission of preparing the best minds in science, engineering, agriculture, and related technological fields. With the currently identified need to rethink and reformulate ways to improve science instruction at all levels, it is essential to further develop and deliver an innovative program that involves a full campus response.

As an outgrowth of a series of Spring 1985 discussions between campus leaders in the College of Education and leaders in the basic and applied science units, including a formal meeting held May 22, 1985, a mission statement (Appendix A) and plan of organization (Appendix B) were prepared for a proposed Center for Science Education. Both the mission statement and the plan of organization incorporate a rationale and scheme for promoting cooperative science and environmental education projects and activities across the KSU campus. Conceptually, an important mission for the Center for Science Education will be to serve as an umbrella for campus organization and to coordinate pre-service and in-service education opportunities for science and environmental education specialists.

CONFERENCE ACTIVITIES

To further validate the mission and plan of organization for the proposed Center for Science Education, a select number of administrators and educators from Kansas, primarily from the Board of Regents' assigned area for KSU--Northeast Kansas, were invited to campus to share their concerns and perspectives on how KSU could best serve the science and environmental education community, both in terms of maintaining quality programs and in the development and implementation of innovative programs and services.

The meeting was structured purposefully so educators from both school and non-formal settings could have an extended interaction with the science education faculty and the various basic and applied science faculties on campus. It was anticipated that a major outcome of the interactions would be a critique of the proposed Center's mission and plan of organization and a set of prioritized recommendations for the mission of the Center for Science Education. The participants were instructed to organize their recommendations to reflect unique needs in four levels of concern: the elementary school, the middle school, the senior high school, and in environmental education/non-formal settings (e.g., environmental education centers, museums, zoos, volunteer groups such as of 4-H club leaders, etc.).

To facilitate the process, four recognized science/environmental education specialists were brought to campus. In addition to formal presentations, each individual worked directly with one or more of the small-group interactions. The individuals were also responsible to draft and admit for review a summary of the small-group working sessions including a distilled set of prioritized recommendations. The resource specialists were:

Elementary School Science Specialist: Dr. Leon Ukens, Professor of Science Education
Dept. of Physics
Towson State University
Towson, Maryland

Middle School Science Specialist:	Mr. Glen Clarkson, Principal Seneca Grade - Nemeha Valley Junior High School Seneca (Kansas) Public Schools
Secondary School Science Specialist:	Dr. Ron Anderson, Professor of Science Education University of Colorado Boulder, Colorado
Environmental Education/Non-formal Education Specialist:	Ms. Barb Stanley Consulting Teacher Outdoor-Environmental Education Topeka Public Schools

Prior to the Needs Sensing Conference each on-campus and off-campus participant received overviews of the proceedings, the preliminary mission statement for the proposed Center for Science Education, and the tentative plan of organization for the Center for Science Education for review. The off-campus participants also received a "Needs Sensing Survey." The surveys were requested to be completed and returned for tabulation prior to the Conference. The results were used by the resource consultants for preparing their introductory remarks and by the four small-group leaders to facilitate discussion.

The Conference began with a goal-setting activity and keynote presentations by the four resource specialists.

During the afternoon session the Conference participants were organized into four groups; each group was assigned the task of "brainstorming" the concerns and needs of educators and administrators in the schools and non-formal settings in terms of science teaching and environmental education. Each group was chaired by a representative from a KSU basic or applied science department. A resource specialist was assigned to advise each group. The groups began their task by reviewing the results of the "Needs Sensing Survey" and the proposed mission statement and plan of organization for the Center for Science Education. Based on the discussion the group was

asked to recommend changes in the mission statement and the plan of organization and to formulate a prioritized list of concerns and needs that could be addressed by the KSU faculty through a Center for Science Education and to report back the findings to the full body of the Conference. The specific questions that follow were provided for each group to consider:

A. RESOURCES FOR LEARNING. In what ways could the Center for Science Education assist in identifying and providing necessary resources for meaningful science and environmental education instruction?
   1. Laboratory and field studies facilities
   2. Classroom facilities
   3. Individual study space
      a. Library
      b. Project areas
   4. Science learning materials
      (e.g., textbooks, films, and other supportive materials)
   5. Science programs to meet the diverse needs of all students
   6. Teacher preparation
      a. Certification requirements
      b. Science content

B. CONDITIONS OF INSTRUCTION. In what ways could the Center for Science Education provide technical assistance for schools in identifying and recommending the necessary educational atmosphere and conditions for learning for meaningful science and environmental education instruction?
   1. Teaching assignments
   2. Working space
   3. Support services
   4. Budget

C. PROFESSIONAL GROWTH. In what ways could the Center for Science Education assist in identifying and providing necessary professional growth of science teachers to enhance meaningful science and environmental education instruction?
   1. Professional library
   2. Continuous learning
   3. Recognition and incentives

During the second day the first task for each group was to review and recommend revisions of the mission statement and plan of organization for the proposed Center for Science Education; particularly, within the context of the specific concerns and needs identified from the previous day.

The second task was to write a position statement that identified the crucial functions that could be performed by the Center for Science Education to assist educators in strengthening science and environmental education program offerings, including specific models for regional and multi-school district cooperation.

Later all participants discussed the written recommendations and position statement developed by each group to further refine the mission of the campus science education and environmental education preparation programs and the goals and objectives for the Center for Science Education.

RESULTS & RECOMMENDATIONS

The recommendations are organized into four sections. Each section contains the summary report and recommendations of one of the four groups followed by the resource consultant's summary and recommendations. Each group during its deliberations was requested to validate the concept of a Center for Science Education by evaluating the proposed mission statement and plan of organization. Each group was asked to focus on the specific aspects of the proposed Center that would relate directly to improving curriculum and instruction at its level of science instruction.

The reports vary in detail and format but each report reflects a consensus of the needs for educators and corresponding strengths of KSU, coordinated through a Center for Science Education, for meeting the needs. The consultants in their reports provided both a synthesis of the group's recommendations and an independent validation of the mission for the proposed Center for Science Education.

ELEMENTARY SCHOOL SCIENCE LEVEL

Elementary Group Report & Recommendations

The final written product for the elementary school group was two statements, one titled "Elementary School Science Needs," and the other titled "KSU Strengths for Meeting the Needs of Elementary School Science." Both documents are aimed at improving elementary science education in Kansas by applying the strengths found at KSU to meet the expressed needs through a Center for Science Education.

I. Elementary School Science Needs
   A. To increase the interest of elementary teachers in teaching science
      1. To increase the use of hands-on activities as a method for teaching science;

      2. To develop teaching skills related to critical thinking (e.g., objectives, plans, evaluation, activities);

      3. To develop stronger content backgrounds. This does not mean just the taking of additional college courses, but rather to

have the content developed in a "team" approach with scientists and science educators, a combination of content and methods.

B. To make available existing resource materials in the areas of instruction, research in science education and science, and aids for administrators to enhance their role in evaluating and supporting science education (e.g., a catalog of what's available and how to access these materials).

C. To coordinate the science programs, K-12.

D. Program and in-service follow-up--the proposed Center should follow up on a continual basis.

E. How to use computers in elementary science education as well as obtaining software for such use.

II. KSU Strengths for Meeting the Needs of Elementary School Science

A. Science and science education faculty

1. The potential for developing and teaching specific science courses for elementary teachers does exist. Science faculty at KSU have an attitude that if a need exists to have undergraduate science content courses made available for elementary teachers in a graduate level course, it can be done;

2. Research and development in science education.

B. Self-contained packages for teaching hands-on activities available through County extension agents. This is a cooperative 4-H extension program.

C. Existing entities such as Kansas Association of Teachers of Science, local science fairs, Kansas Fish and Game, etc.

D. Telenet - an existing teleconferencing system. Capitalizing on telecommunications as they develop through the University and the State.

E. Ability to do workshops at the school sites.

F. Existing public relations programs in the sciences at KSU (e.g., planetarium, science department tours, nuclear accelerator, etc.).

G. Catalogs of existing audiovisual materials and equipment.

Elementary School Resource Consultant's Report & Recommendations

- Dr. Leon Ukens

At a two-day conference at KSU on June 28-29, 1985, a group of professional educators came together to discuss the needs for elementary school science education and the strengths available at KSU and elsewhere to meet

these needs. The elementary science group was one group out of four which met to address needs and strengths in an attempt to validate the goals for a Center for Science Education at KSU. In the discussion concerning elementary school science education, it soon became apparent that there was a consensus (perhaps even unanimous although no formal vote was taken) for the presence of such a Center for Science Education. During several hours of deliberation, the set of needs was developed. The interest, concern, and dedication of the KSU faculty making up this group were outstanding. Their attitude makes the potential for involvement of other KSU science faculty in the future of such a center quite evident. It seemed that whenever a snag was hit in the discussion, a KSU member was instrumental in alleviating it. The desire and ability for improving precollege science education in the KSU service area is definitely there. In addition to helping develop and analyze the needs, the role of the public school teachers and administrators was to keep the group realistic, which they did. The working partnership developed in this group was reflected in many of the discussions.

In determining the needs for elementary school science education, the group paid special attention to the characteristics of exemplary elementary science programs presented to the larger group on the first day by the elementary science consultant. These characteristics were obtained through an analysis of elementary science programs which were deemed exemplary in the National Science Teachers Association/National Science Foundation Search for Excellence in Science Education project. In elementary schools with exemplary science programs:

1. Science <u>is</u> taught, and taught longer.
2. Hands-on experiences are emphasized.
3. Teachers are enthusiastic.
4. Teachers are active professionally.

5. Elementary School Science and Science Curriculum Improvement Study activities are used.

6. Societal issues are frequently studied.

Characteristics of teachers, students, administrators, and the community associated with such exemplary science programs include:

Teachers:
- want to teach science
- are dynamic and young at heart
- provide a stimulating environment
- promote inquiry
- are eager to learn with students

Students:
- actively do science
- identify problems
- make decisions
- learn how to learn

Administrators:
- are supportive of science
- are involved with it
- provide resources for teaching it
- encourage comprehensive teacher in-service

Community:
- recognizes the importance of quality science
- supports school's science program

The underlying concern of the group was that elementary science was an excellent vehicle for having students learn how to learn. While the content may be important, the processes, attitudes and thinking skills should be emphasized. The generated needs were focused with this philosophy in mind.

Recommendations. The following recommendations are being made by the elementary science consultant in light of the two-day Conference:

1. A Center for Science Education should be established at KSU.

2. The Center should be involved in research and development activities in addition to service. Center staff should be careful not to become overcommitted with service activities. Science in the elementary school is different from science taught at other levels because it is being taught by generalists who have numerous reservations about teaching it. The major issue is to get it taught in a manner appropriate to develop thinking skills, processes, and attitudes. Service, therefore, may be initially more important than research and development.

3. An advisory board of KSU science faculty and/or Deans should help the Center develop programs and directions. Public school personnel should also serve on the advisory board.

4. Evaluation of activities of the Center needs to be continuous. Are the needs of the clientele being met?

To summarize, the need exists and the strengths are there to develop and implement a Center for Science Education at KSU. With appropriate and adequate funding to staff such a center, science education at KSU and in Northeastern Kansas should both greatly benefit.

MIDDLE SCHOOL SCIENCE LEVEL

Middle School Group Report & Recommendations

The middle school group examined the special needs of middle school science education and, building on the strengths of KSU, the ways in which the proposed Center for Science Education could help meet these needs. Three general observations seem very important to us:

1. Middle school represents a time of transition in the development of the students and also in the philosophy of education (a shift from student-oriented to content-oriented instruction). Teachers and administrators are often not prepared to deal with the very special nature of middle school students and education in general.

2. Any program to address the needs of science education in middle schools must include administrators as well as teachers.

3. The loss of interest in science often occurs in middle school, and middle school experiences in science have a great deal of influence on the choices students make regarding their high school science classes.

The group divided needs into the following four categories: Teachers/Administrators, Student Involvement, Resources, and Curriculum. Under each category, we looked at the strategies the Center might adopt in order to address the needs in that category. In some cases the need and strategy are essentially the same, and in some cases several needs can be addressed by one or a group of strategies.

I. Teachers/Administrators
   A. Needs
      1. Pre-service and in-service training of teachers and administrators that addresses the unique nature of middle schoolers and middle school education;

      2. Training of personnel to better evaluate the progress students are making in the process of learning rather than simply the mastery of a body of facts;

      3. All persons involved in middle school education must be made aware of the influence middle school science has on students' future academic and career choices;

      4. Interdisciplinary teaching methods that integrate science education with the non-science disciplines;

      5. Middle school certification for teachers and administrators.

B. KSU Strengths/Proposed Strategies
   1. Pre-service training - address middle school needs in elementary and secondary education curricula by providing coursework that requires education students to:
      a. Experience real school situations long before their student teaching;
      b. Experience middle school whether secondary or elementary certified;
      c. Prepare for the possibility of teaching at the middle school; make sure middle school needs are addressed in elementary and secondary courses.

   2. In-service training - the Center can coordinate and provide workshops covering:
      a. Scientific content;
      b. Effective teaching strategies (as indicated in literature);
      c. Communication between elementary trained and secondary trained people;
      d. Effective administrative skills including problem solving, support, management strategies;
      e. Interaction between pre-service and in-service teachers and administrators to bridge the gap between theory and reality;
      f. The uniqueness of the middle school student (psychology, physical development, etc.);
      g. Teaching and evaluating the "process skills";
      h. Interdisciplinary topics and teaching skills;
      i. The decline of enthusiasm for science in students as they progress through the middle school.

   3. Certification - the Center can promote the idea of special certification for middle school personnel.

II. Student Involvement
   A. Needs
      1. Establish science institutes, weekends, workshops for middle school students including teacher involvement;

      2. Deal with reluctance of women and minorities to study science;

      3. Generate excitement (awe) in students about science;

      4. Require science for every student through middle school;

      5. Career awareness.

   B. KSU Strengths/Proposed Strategies
      1. Student workshops -
         a. Follow the model of the Konza Prairie Research Center course for teachers held this year and develop a similar program for students;
         b. Coordinate with other Colleges on campus;
         c. Take advantage of student groups on campus to serve as role models and provide career information (i.e., student geology club, student agronomy club, science education Student Association, etc.);

d. Be sure to involve teachers to interpret the material to middle school students.

2. Minorities and women -
   a. Draw on the resources provided by the Women's Studies Program, the Women's Resource Center, the Women's Education Equity Act group in the Department of Curriculum and Instruction, Ethnic Studies, and other such groups on campus to provide a better understanding of the special needs of minorities and women and how they relate to science instruction;
   b. Expose teachers to current theories about unconscious sexism and racism, sex-role socialization, and their effects on teaching and learning;
   c. Develop an annotated bibliography of female and minority scientists, those who are covered and those who are ignored by traditional science curricula;
   d. Examine methods to deal with science-anxiety among teachers, especially those with primary school and elementary school training.

3. Excitement -
   a. Provide students with the opportunity to experience the excitement of science; the workshops in 1 above would provide one possible mechanism for this;
   b. Provide techniques, examples, etc., for teachers to use.

4. Required science classes - the Center can promote this idea.

5. Career awareness -
   a. Create slide presentations and videotapes illustrating scientific careers;
   b. Organize and sponsor career days where students can interact with scientists and learn about careers in science. We often focus on high school students but neglect younger students in such activities.

III. Resources
   A. Needs
      1. Provide teachers with information and evaluation of new and existing materials, including materials for special populations;

      2. Networking: workshops, people, resources, satellite centers;

      3. Involve non-educational sources (industry, foundations, public);

      4. Periodically evaluate Center's goals and effectiveness.

   B. KSU Strengths/Proposed Strategies
      1. Materials -
         a. Create and maintain a resource pool of up-to-date materials for science education at the middle school level;
         b. Allow for teachers to test the materials through workshops and in-class experience.

2. Networking - largely including the items listed in the needs above.

3. Non-educational sources -
   a. Compile an annotated resource listing and make it easily available to teachers and administrators;
   b. Help teachers acquire the skills needed to identify and obtain help from local sources;
   c. The Center may coordinate a speakers bureau involving University and non-University personnel (similar to but more structured than the Science Outreach Program).

4. Review of Center's activities - hold a conference similar to this one every two years or so to reevaluate needs and strategies and to see how well the Center has accomplished the goals set for it.

IV. Curriculum
   A. Needs
      1. Define appropriate content and instructional strategies for middle school;

      2. Continuity of science K-12;

      3. Develop appropriate materials with and for middle school teachers (age, special populations).

   B. KSU Strengths/Proposed Strategies
      1. Content and strategies -
         a. Bring in practicing teachers for their input;
         b. Organize a forum to work on an "ideal" curriculum as a model for others;
         c. Assist school districts in defining their <u>own</u> needs and wants and help in the implementation;
         d. Sponsor a workshop between teachers and publishers to help put the developed ideas into print in textbooks.

      2. Continuity -
         a. Provide resources to help schools assess and coordinate their programs;
         b. Work in two directions, workshops at the Center and resource people to visit the schools;
         c. Involve administrators.

      3. Materials -
         a. Emphasize the "hands-on" approach;
         b. Organize teams to develop materials, including teachers, scientists, education faculty;
         c. Develop a program to field-test the materials;
         d. Train teachers in the use of the materials;
         e. Have a mechanism to inform teachers of the availability of the materials.

Middle School Science Resource Consultant's Report & Recommendations

- Mr. Glen Clarkson

I would like to thank you for inviting me to be a part of the Science Education/Environmental Education Needs Assessment Conference. It was a well planned and meaningful Conference. The high level of interest and cooperation by the participants verified the preconception that a need exists for a Center for Science Education along the proposed lines.

A conference of this type has the potential of being a "rubber stamp" process. Due to the format and willingness of the organizers to allow each sensing group to function with minimum guidelines, there was an open and honest reflection of the participants' opinions collected in each group's summary report. It is noteworthy that each of the four groups (elementary, middle school, high school, environmental education), while working independently at the Conference, developed very similar needs and strategies to be served by the Center. It is also a reflection of your insight that these developed needs and strategies fall very close to the original proposed mission statement areas of: instruction, research, development, and implementation and services.

The high level of willingness by the participants to not only verbally support the science center concept but to personally want to be a part of its formation and operation was refreshing to see. As two examples, Dr. Graf of Geology and Dr. Coffman of Veterinary Medicine were actively listening to the precollege school needs and suggesting ways they could provide meaningful services through the center concept. Specific examples of ways they proposed to participate were to work through the Center with their respective Colleges providing the resource people for teacher/student in-services and workshops.

The concept of a variety of specific topic in-services for teachers received extensive support as a way to provide teachers the needed in-depth

knowledge. The traditional format of college courses is not compatible with practicing teachers' real world. Also the idea of expanding on-campus workshops for middle school and high school students received widespread support. This was viewed as a way to give students a more realistic feel of science and to heighten their interest in science.

Throughout the Conference I was amazed and pleased that participants, at all levels, did not see "science content" as the most important concern of education. I was hearing (a) that it is important that elementary/secondary students have "good" experiences with science, (b) science is an important part of a person's total education, (c) that above all else students feel excited about science and want to learn more, (d) that science knowledge without communication skills is of little value, (e) that students be critical thinkers and understand how to acquire knowledge, and (f) that students have a realistic understanding of what is involved in the various areas of science so when they enter college programs they can make reasonable, realistic, and satisfying choices.

A spin-off benefit of the Conference, that I observed, was the "getting-together" of representatives from the College of Education and the various basic and applied science Colleges on campus. There were many exchanges of ways they could cooperatively benefit each other and students. The cooperative atmosphere was very prevalent.

A review of the sensing group reports provides a wide variety of meaningful services that can be initiated by the Center for Science Education. Based on the cross section of support observed at the Conference, the demonstrated leadership, the on-campus support both in the College of Education and the various colleges in basic and applied sciences, and the projected mission(s) set out for the Center, I fully support the Center's establishment. I realize that process will require extensive time and effort

on the part of the KSU faculty and administrators. Feel free to call on me to help as you feel appropriate.

As the Center has the potential to provide a much needed supporting role for education in Kansas, I would be willing to serve on an advisory type council if you so desire.

HIGH SCHOOL SCIENCE LEVEL

High School Group Report & Recommendations

The group believes that all major categories of needs are equally important. The strengths for meeting the needs will come primarily from the KSU faculty and programs.

I. Professional Development Needs of Practicing Teachers
   A. In-service resource
      1. Strengths:
         Science Education facilities and faculty

   B. Interaction with other teachers and with specialists
      1. Strengths:
         Regents' telenet system, Kansas Association of Teachers of Science, Kansas Junior Academy of Sciences (directed through KSU)

   C. Significant knowledge about science and science education
      1. Strengths:
         KSU faculty, library, grass and grain, departmental seminars, visiting lecturers

   D. Short courses on and off campus
      1. Strengths:
         Telenet system, interactive video project, cable TV, existing KSU courses

   E. Fellowships and/or sabbaticals for practicing teachers/personnel exchange
      1. In the Center for Science Education

      2. Coordinate with industry and research laboratories

      3. Summer employment in industry and research laboratories
         a. Strengths:
            Industry interest, available internships, KSU research programs

II. School Science Program Improvement Needs
   General Strength: Science Education Faculty
   A. Assistance in reviewing and evaluating school programs
      1. Strengths:
         Center for Extended Studies and Services

   B. Assistance with implementation of programs
      1. Strengths:
         Models available from professional organizations

   C. Studies and recommendations on science policies (school, district, state)

D. Guidelines for science teaching
   1. Strengths:
      Guidelines from professional associations

E. Recommend "core" curriculum

F. Help on defining goals

G. Demonstrate and evaluate curriculum materials
   1. Strengths:
      KSU Curriculum Library; Library collection of education and science education journals

III. Instructional Resource Needs
A. Application of science to personal and societal needs
   1. Strengths:
      Agriculture in other disciplines project
      University for Man appropriate technology project
      4-H science-related programs
      "Agriculture Today" on the KKSU radio station
      New curricula
      KSU faculty
      Science and science education literature

B. Classroom applications of significant science content
   1. Strengths:
      Curricular material
      Science education literature

C. Ways to motivate and stimulate students
   1. Strengths:
      KSU Chemistry Quiz Bowl
      Honors Science Colloquium on Telenet
      Field trips to teaching and research facilities at KSU
      Scouts, 4-H, etc.
      Science and Engineering Day at KSU

D. Resources for independent study science projects
   1. Strengths:
      KSU Faculty
      Kansas Junior Academy of Science

E. Speakers bureau (from both campus and industry)
   1. Strengths:
      Faculty, other scientists and engineering

F. Career information for students who wish to be scientists, engineers, and science teachers
   1. Strengths:
      KSU faculty
      Department P.R. literature
      Professional Association literature

IV. Development of Profession Needs
A. Advocacy for the profession (science education)
1. Strengths:
KKSU
KTWU
Available P.R. for science and engineering
Video segments in coaches' programs

2. Liaison and leadership with present professional organization
a. Strengths:
Faculty is already active

3. Participation in development of professional standards (certification)

V. Research and Development Needs
A. Matching how we teach with what we know about students

B. Research and evaluation on validity and content of competency tests
1. Strengths:
Testing and measurement in the Department of Administration & Foundations

C. Curriculum materials
1. New, innovative
a. Strengths:
KSU Chemistry's lab program

2. Adaptation

3. Revision for specific needs of rural areas
a. Strengths:
Center for Rural Education
University for Man Liaison with rural communities

D. Instructional delivery systems to students
1. Strengths:
Interactive video project in the Physics Department

E. Research on how students learn science
1. Strengths:
Interest among science and science education faculty

VI. Pre-service Teacher Education Needs
A. General Strengths: Existing science education curriculum
1. Liaison to general education (liberal arts) faculty

2. Teaching speciality

3. Professional education, including field experience

High School Science Resource Consultant's Report & Recommendations

- Dr. Ronald P. Anderson

I appreciated the opportunity to participate in your Conference and see the impressive progress you are making toward establishment of a Center for Science Education. As a follow-up to the Conference I will provide in this memo some of my specific reactions to the Conference and make some suggestions for future actions. Since you have a detailed report of the high school group deliberations, I will not attempt to duplicate that information here.

Several matters particularly impress me about what you are doing. First, the basic idea for a Center for Science Education is both well-conceived and timely. The mission statement describes a Center that is viable and has great potential. It is particularly timely given the great needs in science education that are now recognized and the substantially increased amount of federal funds now available. Second, I was impressed with the process you are using to develop plans for the Center and get it established. You are taking the time-consuming but necessary steps to obtain the cooperation of University and school personnel and to develop workable plans for the Center's operation. Finally, I was particularly impressed with the cooperation and support you have received from the science and science-related departments across campus.

Having stated my overall enthusiasm for what you are doing, let me go on to offer some suggestions for your consideration. One is that you give careful attention to the means by which the Center will be governed and receive guidance for its operation. Given its focus on service to schools, some means must be developed by which the Center will be influenced by the schools it serves. Research clearly shows that successful school improvement endeavors must be based on local initiative. If the Center is to produce

results, it must have mechanisms, such as a possible advisory council of school representatives, which direct it toward the assistance schools both need and want.

A related matter is the role the Center will play within the University. Given the University's three-part role of teaching, research and service, careful attention should be given to identifying those service needs which are of high priority to the schools and also are complementary, within the University, to the institution's teaching and research functions. Ideally, the service activities undertaken will enhance the research and teaching activities of the Center's personnel. Some of the service activities, for example, may provide opportunities for faculty and graduate students to conduct some of the applied research which they typically would pursue. Similarly, these activities in turn would enhance the teaching function as it pertains to graduate students.

Given the above considerations, I think it is important that you carefully select a few activities to provide the focus for your work in its initial stages. Rather than trying to be all things to all people, carefully selecting a few key activities has far more potential. Among the criteria to employ in selecting them are the following:

1. These services activities complement your teaching and research functions;
2. They are tied in some way to local initiative within the school districts; and
3. They are part of a systemic endeavor.

This latter point deserves further elaboration. Research shows rather clearly that <u>single</u> activities intended to improve education are unlikely to have much impact. It takes a <u>coordinated set</u> of activities in the schools that extends over a long period of time. The key to success of the Center may well be tied to the mechanisms you establish for identifying those

activities which build on local initiative, are long-term, and together within a given school district stimulate an appropriate coordinated set of improvement endeavors.

The final point in this memo deals with funding. We have entered a time where it appears there will be a significant amount of federal funding available. The majority of your activities potentially can be supported by these funds, either received directly from the Federal Government or in the form of funds that flow through your State Department of Education to you or cooperating school districts. I think it would be a serious mistake, however, to imagine that the Center could be supported entirely by these funds. I think you need a core of University funds to give you stability and provide a foundation you can use in competing for the external funds.

Good luck on this worthy endeavor.

ENVIRONMENTAL EDUCATION/NON-FORMAL EDUCATION LEVEL

Environmental Education/Non-formal Education Group Report & Recommendations

The final written product of the group is the preparation of a mission statement for the environmental education/non-formal education component of the Center for Science Education. This mission statement is a compilation of the identified needs for environmental education that the KSU faculty can deliver through a campus-wide Center for Science Education. (Note: Items are arranged in order of priority of task force members. Categories are noted in the margin.)

Instruction and Service)

I. Need - Facilitate, conduct, and identify seminars, conferences, and hands-on workshops related to environmental education
   A. Publish monthly newsletter
      1. Include activities of Center;
      2. Include workshops, etc., of other organizations, e.g., Kansas Advisory Council for Environmental Education, Kansas Association of Teachers of Science, etc. (clearinghouse function);
      3. Send to appropriate school district person, e.g., science contact person, or NEA building representative--not superintendent.
   B. Facilitate and conduct research-supported programs.

Service)

II. Need - Catalogs
   A. Prepare an illustrated catalog of local sites suitable for field trips with a list of possible educational objectives to be met at each site.
   B. Identify local resource people and materials
      1. Update KSU's Farrell Library collection;
      2. Update KACEE Directory;
      3. Networking.

Instruction and Service)

III. Need - Provide and identify college and equivalency credit courses and programs
   A. Conduct courses on and off campus.
   B. Compile in above-mentioned newsletter master list of courses available in and out of state.

Service)

IV. Need - Materials and supplies
   A. Develop and maintain a curriculum materials center.

B. Assist teachers in identification of sources of supplies and in how to use materials.

Service) V. Need - Establish a referral and consultant network to assist teachers with students
A. Identify teachers and professors willing and available to demonstrate expertise with students in field.

B. Identify adjunct people (zoo, museum, agency, centers, etc.) willing and available to demonstrate expertise with speciality.

Service) VI. Need - Provide information regarding environmentally related careers
A. Produce videotapes (more effective than pamphlets).

B. Incorporate candid insights of persons working in given career.

Research) VII. Need - Develop exemplary grade level goals and objectives for environmental education
A. Utilize College of Education expertise.

B. Adapt objectives developed by USD 501 to multi-district use.

C. Refer to Department of Education guidelines.

Service) VIII. Need - Assist school districts in identifying potential private and public sources of funding
A. Create an awareness of kinds of sources available.

B. Develop a pamphlet on grantsmanship.

Research) IX. Need - Generate research in environmental education application
A. Serve as two-way communication service between school districts and University in identifying research needs.

B. Communicate research results to teachers.

Service) X. Need - Generate good public relations for environmental education
A. Help districts get the word out about the merits of non-formal education.

B. Utilize influence of University in this regard.

<u>Environmental Education/Non-formal Education Resource Consultant's Report & Recommendations</u> - Ms. Barbara Stanley

I. Meaningful Environmental Education

In the context of a basic premise of any environmental study, interaction and interdependence, environmental education epitomizes that concept. In order for environmental education to be at its best, there must exist an interaction among a web of many factors.

The focal point of the web is the student. Environmental educators incorporate everything they know about child development and learning theories in order to "turn kids on" to life and learning. In the next corner of the web is the teacher. The teacher must be enthusiastic, knowledgeable, and secure in his/her ability to teach in a non-formal way as well as by traditional methods.

The line between student and teacher is made stronger by the other corners of the web. In these strong supportive roles must be the school board and administration, teachers of other disciplines, and support personnel. The web is made even stronger if there is strong community support from both the public and private sectors, availability of current research results, and resource specialists in tune with the goals of environmental education.

Another major premise of environmental education is the concept of continuity and change. Continuity in environmental education can be achieved through the development and use of goals and objectives. In this day of accountability, teaching by objectives is helpful--especially in a field that is considered non-formal education. Both affective and cognitive goals can and should be addressed and measured in environmental education.

"Change" is considered here in the context of "change of public attitude" away from environmental issues. The issues are more "basic" in the eighties (and will be in the future) than they were in the seventies when "environment" was the magic word. Therefore, the inroads that have been gained in environmental education must not be lost; rather further gains must be made. Environmental education must be considered a multidisciplinary synthesis of the body of knowledge and recognized as potentially education at its best.

II. The Center for Science Education

For all of the above reasons, a facility such as the Center for Science Education is needed. As conceptualized by the faculty at Kansas State University, the Center can be a very positive force in making environmental education all that it can be in Kansas.

The Kansas State University College of Education's generating the process, wherein participants from an impressive number of Colleges of the Kansas State University campus and from off-campus school districts and organizations came together to discuss what is needed to realize exemplary science programs, was an exciting happening for education in Kansas. Presentations from outside specialists and discussions of needs and strengths of the four areas (elementary, middle school, high school, and environmental science) among all of the participants led to the validation of the existence of the Center for Science Education. In each of the four areas it was strongly indicated that a very positive force toward exemplary science education in Kansas can be realized through the cooperative efforts of higher education, school systems, and the community.

The cohesive force to bring these components together in a common endeavor is what is needed in Kansas, and the Center can provide this cohesiveness. The Kansas Advisory Council of Environmental Education has perceived this need for several years. It has not been met. To have the generating effort come from higher education as it has from Kansas State University is most progressive in meeting the objective of all working toward common goals of excellence in education. The Center can provide the impetus that is needed.

Indeed, the process of finding needs, strengths, and mission as a common endeavor at the June 28-29, 1985, Conference was a powerful catalyst in bringing higher education, school systems, and the larger community

together for the amelioration of science education. The cooperation of the Graduate School, the School of Veterinary Medicine, the School of Arts and Sciences, and the College of Engineering was indicative of the high priority the entire University places on this endeavor and of the potential for future work toward the common goal. Most impressive!

The forum for communication among educators of all levels and from various fields of scientific endeavor had side effects above and beyond the stated mission of the Conference. It was perceived that through this and possible future interactions, a continuity of understanding and mutual respect will lead toward very real positive change in the future. Recognition of interdependence has been recognized.

END NOTES

1. National Science Board Commission on Pre-college Education in Mathematics, Science, and Technology. (undated). Educating Americans for the 21st century: A plan of action for improving mathematics, science and technology education for all American elementary and secondary students so that their achievement is the best in the world by 1995. Washington, DC: Author.

2. Education Commission of the States, National Assessment of Educational Progress. (1983). Three national assessments of science: Changes in achievement, 1969-77 (Science Rep. No. 08-5-00, June, 1978). Minneapolis, MN: University of Minnesota, Minnesota Research and Evaluation Center, Images of Science.

SUMMARY

The Science Education/Environmental Education Needs Sensing Conference, organized by the College of Education, brought together faculty from the various colleges of Kansas State University and off-campus school districts and organizations to discuss what is needed to realize exemplary science education and environmental education programs in Northeast Kansas, and to evaluate the need for the establishment of a Center for Science Education at Kansas State University. A primary concern expressed throughout the Conference is the great need for a long-term and systematic cooperative effort between higher education and the science and environmental educators in the elementary, middle, senior high schools and non-formal settings to find the most progressive ways in meeting the expectations of everyone working toward common goals of excellence in education.

The major conclusion that came out of the Conference is that there is a real need for a campus-wide Center for Science Education at Kansas State University. The Center could provide the positive, cohesive force to bring together, in a common endeavor, those who have the commitment and skills for achieving their potential in science education and environmental education in Northeast Kansas.

It is interesting to note that each of the four groups (elementary, middle school, high school and environmental education/non-formal education), while working independently, developed very similar needs and strategies to be served by the Center. The needs and strategies were found to be in close harmony with the proposed Center's mission statement components of: instruction; research, development and implementation; and service (see Appendix A).

In organizing the Center it was concluded that a broad-based advisory board should be formed to review and recommend Center policies and activities. To be effective, the advisory board's membership should come from public

school teachers and administrators, non-formal educators, and representatives from business, industry, the Kansas State Department of Education and appropriate scientific and education professional societies.

It was recognized that the Center, in effectively responding to the needs of educators, must work within University policy. Given the University's three-part role of teaching, research and service, careful attention must be given to those service needs which are of the highest priority to the educators in various settings and are also compatible, within the University, to the institution's teaching and research functions.

The Center staff must work closely with educators in the field in planning meaningful service activities that will have a lasting and positive effect on teaching practices. Research shows rather clearly that isolated activities of short duration intended to improve education are likely to have a poor reception and little impact. It takes a long-range, integrated plan that is implemented systematically over a long period of time.

Appendix A

Mission Statement

The mission of the Center for Science Education at Kansas State University (KSU) is to facilitate collaboration between individuals and units on- and off-campus for the purpose of creating, implementing, evaluating and disseminating models for teaching theoretical and applied science concepts and principles to individuals; focusing on both schools and non-formal educational settings (e.g., nature centers, youth organizations, museums, zoos). Because of Kansas State University's status as a land-grant institution, the Center is committed to solving the special needs of schools in Kansas and the Plains States, including the needs of unique groups, e.g., urban schools, minorities and underrepresented populations in the sciences, rural and small schools, and non-school/non-formal instruction. The mission, related to science education, science, engineering, agriculture and interdisciplinary environmental topics, involves three components: instruction; research, development and implementation; and service.

Instruction

Coordinate the development and offering of undergraduate and graduate programs designed to prepare professionals from various pedagogical settings and levels to carry out leadership roles in the instruction of the theoretical and applied sciences and interdisciplinary environmental topics.

Facilitate opportunity for the involvement of on- and off-campus educators in research-supported pre-service undergraduate programs for elementary, middle school and secondary instructors of science and environmental education, and for educators working in non-formal settings.

Research, Development and Implementation

Provide opportunities for the Center faculty to work with science and environmental educators and the KSU faculty and students to evaluate existing ideas in theoretical and applied sciences and pedagogy to create

and disseminate new knowledge, and to plan and coordinate the incorporation and utilization of new ideas, strategies and materials into existing educational settings. This includes opportunities for experimental teaching, research projects in school and nonschool instructional settings, curriculum development and implementation, program and staff evaluation, and teacher education.

Service

Promote cooperative activities with the KSU theoretical and applied science units, the Kansas State Department of Education and other state, local, regional and national educational agencies; including consultancies, workshops, internships and courses of study.

Facilitate interaction of Center faculty and students with governmental and professional organizations associated with the theoretical and applied sciences, environmental education and science education locally, nationally and internationally. Assist individuals and professional groups in promoting careers in the theoretical and applied sciences and in science and environmental education.

Make provisions for assistance with, and access to, the science and environmental education professional literature housed within the Center, and other units on campus. These collections include reference books, textbooks, journals, curriculum guides, ERIC/SMEAC collections and numerous other important documents.

Disseminate programs, materials and other resources for improving science and environmental education instruction. Serve as a clearinghouse for requests concerning information about equipment and supplies. Provide a demonstration site for new and innovative instructional technology and programs. Assist educators with the implementation and continued utilization of these resources within their educational settings.

Appendix B

Plan of Organization

The Center for Science Education at Kansas State University will focus its leadership activities in the areas of (a) Instructional Programs for the Preparation of Science and Environmental Educators; (b) Research, Development, and Implementation of Science and Environmental Education Models and Materials; and (c) Innovative In-service Programming. The following organizational plan will serve to coordinate activities across all three functions.

Administrative Organization

The Center will be lodged organizationally within the College of Education, and alongside the various education, basic science and applied science departments on the Kansas State University campus. Through staffing arrangements the Center will remain integrated with these existing units ensuring wide University involvement and commitment. Institutional support supplemented by grants will finance permanent Center administrative and support staff. Permanent staff, when the Center is totally operational, will include a director responsible for overall Center operations and for instruction and research and development activities, an associate director responsible for implementation and in-service, and faculty from across campus who have formally committed a portion of their time to Center activities. Support personnel will include a secretary, a resource librarian and dissemination specialists.

Staffing of the Center Within a Project Framework

Activities of the Center will be organized around special projects in the areas of instruction, research, development and dissemination/implementation for elementary and secondary schools. Projects will vary in length and scope and will vary over time as new problems are identified for research and development and as solutions from R&D activities are made ready for dissemination to elementary and secondary classrooms and other educational

settings. Staffing of the Center will take advantage of the strengths in the present science, science education and environmental education faculties on the Kansas State University campus. Interested faculty from the College of Education, the College of Veterinary Medicine, the College of Engineering, the College of Arts and Sciences, the College of Architecture and Design, and various extensions services will affiliate with the Center for various projects.

The Center membership will be composed of faculty who hold a permanent rank of instructor or above, with either a full-time appointment in the Department of Curriculum and Instruction (EDCI), a joint appointment between EDCI and another campus department, or a full-time member of another campus department who affiliates with the Center because of interest in science and/or environmental education. In addition, science, environmental education and science education scholars and researchers from outside the University are invited to hold adjunct appointments at the rank commensurate with the individual's qualification.

As monies become available, short-term fellowships and visiting professorships will be created to bring to the Center professionals with expertise in the areas of Center responsibilities. Fellowships and visiting professorships will be of varying length to permit researchers, development specialists, school system resource people, classroom instructors, non-formal educators, and state department program specialists to join the Center from their permanent assignments to work on identified projects. These professionals will not only bring unique experiences and skills to accomplish the aim and scope of work identified by the Center's projects, but also will take valuable experiences back to their permanent assignments. In addition, the project-focused organizational structure will allow the Center to expand and contract according to current resource support and allow the Center needed

flexibility to move quickly into new arenas of research and development activity.

Governance

The chief administrative officer of the Center will be the Director responsible for the Center's mission and overall scope of work and for coordinating and involving project staff and fellows in the continuing definition of the Center's mission and activities.

An Advisory Committee made up of campus representatives, school administrators, scientists, science teachers, environmental educators, representatives from the State Department of Education, leaders in professional science associations, teacher educators and researchers will provide exchange between the Center and client groups. The Advisory Committee will meet no less than twice a year to discuss the Center's mission, projects, activities and evaluation.

Long-range Institutionalization and Funding

It is envisioned that the Center for Science Education will remain permanently on the Kansas State University campus as long as the need for research and development in environmental and science education exists. A diversified funding base consisting of state and university monies; and research, development and instruction contracts will provide for the Center's permanent existence and institutionalization.

RURAL EDUCATION: A PROUD HERITAGE AND A BRIGHT FUTURE

Eighth Annual
Rural and Small Schools Conference

Kansas State University
October 27-28, 1986

ABSTRACTS

Science Education Section
Conference Co-Chairpersons

Dr. Larry G. Enochs
Dr. Emmett L. Wright

Craig A. Berg
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Hungry for Information? Grab a Byte of This!

Presentation will be a description and demonstration of a computer-modem assessable information-resource data base. This data base assists teachers who are searching for appropriate materials or resources that can be used in the science classroom. It also provides a medium for teachers to form support groups and exchange ideas, information, etc.

This information resource network is especially valuable for small school teachers who are isolated from the main stream of science education. It allows them to remain aware of new and alternative approaches to science teaching.

Betty L. Bitner
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Southwest Missouri State University
Springfield, MO 65804-0095

Critical Thinking Skills: A Model for Rural Schools

This presentation will provide an overview of the Critical Thinking Skills Grant funded by the Winthrop Rockefeller Foundation and will engage the conference participants in using critical thinking skills. The three year grant involves K-12 teachers in rural Arkansas.

The Bitner Model of Critical Thinking Skills will be used to analyze environmental and energy issues pertinent to rural America. The Bitner Model is based on developmental psychology, theories of intelligence, learning theories of intelligence, learning theories, and current research on critical thinking skills. The Bitner Model has a twofold focus for utilizing critical thinking skills: problems with a definite solution and real life problems with no absolute solution due to their contextual dependency. The Bitner Model emphasizes that the teacher is the model in the critical thinking process.

Betty L. Bitner
412 Hill Hall
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Year Long In-Service Science Workshops: Their Effect on the Attitudes of Teachers K-7 Toward Science and Science Teaching

Emotional intensity or attitude toward science and science teaching influences the teaching of science--whether it is taught and how it is

taught. Both preservice science education and inservice science education have been recommended as means for changing attitudes toward science and science teaching.

The sample in the present research consisted of thirty-three K-7 teachers (eleven K-3 and twenty-two 4-7) in the Pope, Yell, and Conway Counties of Arkansas. Three null hypotheses were tested (1) The year-long inservice science workshops will make no significant difference in the attitudes of K-7 teachers. (2) There will be no significant difference in the attitudes of teachers under forty years of age and of teachers over forty years of age. (3) There will be no significant difference between the K-3 and 4-7 teachers. The Science Attitude Scale for In-Service Elementary Teacher II, a twenty-six item Likert-type scale (sixteen positive and ten negative statements), was administered to the sample during August, 1985 and again during April, 1986. The treatment consisted of the following required sessions: one full day and five half days of workshops, and one all day field trip. Also offered were two optional all day Saturday field trips, one on the formation and uses of minerals and rocks and the other on wildlife and the environment. The workshop and field trip topics were correlated with the Arkansas Grades 4-6 Basic Science Skills Objective which focus on biological, earth, and physical sciences.

The range of the item total correlations on the pretest was -10 to .79. Only statements 1, 3, 13, 15, and 20 dropped below the .30 level. The range of the item total correlations on the post-test was .17 to .70 with only statements 4 and 25 falling below .30. Statements 21, 25, and 26 on the pretest and statements 6, 10, 13, and 26 on the post-test received beyond 35% in the neutral interval. The first hypothesis was rejected ($\bar{I}$ -value = 2.02, $p < .0250$). The second and third hypotheses were accepted. The results of this study seemed to indicate that inservice science workshops can have a positive influence on the attitudes of teachers toward science and science teaching. Further analysis of the statements with neutral responses beyond 35% is needed.

Sandy Allieu Bockarie
Science Curriculum Development Centre
Njala University College

Profile of a Rural Technology Curriculum Package as a Component in a Primary Teacher Training Programme

This paper presents a description of the elements and their characteristics of a small component (a rural technology curriculum package) of an innovative training programme for primary teachers in Sierra Leonean schools. It is the product of documentary analysis by the Rural Education Evaluation Project, a research activity by the University of Sierra Leone that is sponsored by the International Development Research Centre of Canada.

The paper provides a brief description of the newly proposed Teachers Certificate Teacher Training Programme in the UNDP/UNESCO assisted Bunumbu Project (SIL/74/009) (Training of Primary School Teachers for Rural Areas) at

Bunumbu Teachers College. Bunumbu is a pilot programme of teacher training for the Sierra Leonean situation intended to improve rural living conditions through elementary education. The place of the rural technology curriculum package is illustrated in the paper, especially its links with other areas of the teachers training (e.g., practical teaching and Arts and Crafts). The concept of integration resulting from these linkages in the programme is depicted as distinct from the cross-subject approach to integration that was used in the development of the primary school curriculum component corresponding to the newly trained teachers by the project.

The Rural Technology Curriculum Package is presented as part of the course in Community Development and Adult Education (CDA) and is taught by the use of a Rural Technology Research Laboratory which functions both as an adult education and a professional teacher training unit in the college. Students of the college pursue the Rural Technology Curriculum Package as part of the CDA course through supervised practical at the research laboratory. And it has been discovered by the Rural Education Evaluation Project that the form of integration adopted by the teachers who graduate from the programme is the direct result of the practical nature of the training received.

Robert D. Boram
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Adapting and Implementing a Laboratory-Based High School Science Program in a Small School

Research has indicated that using a laboratory-based science curriculum which incorporates the learning cycle is more effective at enhancing concept understanding than a traditional lecture approach. Further research has found a link between the concrete and formal Piagetian stages and science concept attainment. Using Piagetian research as a theory base, the Science Education Center at the University of Oklahoma and the Science Department at Norman High School developed three laboratory-based science courses which make use of the learning cycle. The curriculum includes physics, chemistry, and biology courses.

The proposed presentation will describe the successful implementation of this curriculum in a small (average of 12 students per science class) private school in Oklahoma. Specific benefits and problems will be discussed, including:

- increased interaction with students
- improved student attitudes toward science
- start-up and maintenance costs

In addition, suggestions will be made for the modification of the program for the college-bound student. Students' comments and reactions to the program will also be shared.

Glenn H. Crumb
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Using Networks for Program Development

The presentation will illustrate how networks are used for the following: improve school programs in the basic skills (mathematics and science included); develop and test curriculum materials; service needs of teachers in the field for non-credit course or workshop experiences; and support teachers of science and mathematics in subject areas by maintaining contacts with University centers.

Larry G. Enochs
Center for Science Education
Kansas State University
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The Role of the Consultant in the Improvement of Rural Science

This paper involves the role of the university consultant in school improvement efforts in rural schools. University consultants are external change agents and should have specific roles if they are to be effective in local improvement efforts. This is particularly true in the case of rural/small schools where proximity to universities is often a problem. The suggestions of Karen Seashore Louis in her article, "The Role of External Agents in Knowledge Utilization, Problem-Solving, and Implementation of New Programs in Local School in Texts," will be synthesized and reported. These include:

1. Prior negotiation of specific roles before providing services; and
2. Successful consultants use feedback from clients to adapt their strategies.

The impact of outside consultants depends upon the consultants' past experience, personal characteristics, and strategies used. Consultants are necessary for change but their effort depends on linkage to the local situation through internal leaders.

Kevin Finson
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Teacher Education in a Small Rural College

Small rural colleges face many of the same challenges in education that confront rural elementary and secondary schools --including widely dispersed student populations, lack of networking between schools, little flexibility in monies allocations, large distances between attendance centers,

professional isolationism, and the need to find and retain qualified faculty capable of teaching a wide range of subjects -- particularly the sciences.

These types of rural problems impact teacher education programs at small colleges in rural settings. The small college must develop programs capable of producing the types of teachers required in their regions while at the same time conforming to budgetary time, and faculty limitations which impact such colleges far more than in more populous college areas.

The problems facing rural colleges in providing in-service to rural teachers, developing and disseminating science curriculum innovations to rural schools, developing research strategies (and conducting research) from such colleges, and other pertinent concerns all vary from similar problems encountered by larger colleges. These problems will be presented and discussed, with one goal of the discussion being the generation of ideas and/or strategies useful for establishing objectives attainable by small rural colleges for the improvement of the efficiency and effectiveness of their teacher education programs, particularly in the science disciplines.

Jack A. Gerlovich
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50 Safe Physical Science Activities for Teachers

This session will focus upon software programs developed to assist teachers, school boards, and administrators in addressing the problem of safe physical science activities for teachers. The software includes text dealing with the following chapters: Science Teaching and The Law - What's The Connection, The Learning Environment, and Instructional Materials. In addition, checklists are provided for the classroom, laboratory, preparation room, storeroom, and field trips. Both elementary and secondary versions of the software will be presented. The author has written 5 safety books, 25 journal articles, conducted 50 school safety assessments, and defended science teachers in court.

Ray E. Hull
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University of Oregon
Eugene, OR 97430

Lane Regional Science Cadre

The Lane Regional Science Cadre represents a joint effort of the University of Oregon, Lane Community College, Lane Education Service District, and school districts in Lane County, Oregon. Its purposes are to: (1) create a group of teachers with enhanced skill and knowledge for teaching intermediate grade science, (2) develop science training and teaching materials consistent

with the focus of the Cadre, and (3) increase cooperative relationships and interactions in the area of science among the participating school districts.

In order to achieve these purposes, exemplary teachers in grades 4-8 are selected to participate in a summer training program accompanied by follow-up sessions during the school year. Training focuses on current needs in science, strategies for teaching science, and strategies for staff development and inservice delivery. Once trained, these cadre members, in turn, provide consultation and inservice training in science to their peers in the participating school districts. This peer training may take the form of inservice presentations to large groups, individual teacher assistance, a series of classes or workshops, or assistance in planning and conducting long-range inservice programs and activities in their districts.

Materials developed and disseminated by the Cadre include lesson plans, resource guides, demonstration plans and apparatus, teaching guides, and activity collections. The Cadre focuses on "hands-on" activities which may be applied directly in the classroom.

During the 1985-86 school year, the Lane Regional Science Cadre provided inservice to approximately 400 teachers in the 16 school districts of Lane County. Evaluation indicates that the training of the Cadre itself was effective and that services provided to classroom teachers by the Cadre did in many cases influence their science teaching or curriculum.

Harry McAnarney
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The Discrepant Event and the Teaching of Science in Rural and Small Schools

Most students will benefit from an appropriate use of the discrepant event. A major decision facing teachers relates more to how and the extent to which the activity should be used than to whether it warrants utilization. A commonly accepted definition views the discrepant event as a situation which presents an inconsistency between what people believe will happen and what actually happens; the result being an unexpected outcome that does not make sense. Among the favorite discrepant events are the egg and the bottle, attempting to blow a ping-pong ball upward out of a funnel, and estimating how many drops can be placed in a container apparently already filled with water.

The discrepant event serves as an excellent interest-getter or grabber, a motivator, and as a springboard to other activities. Its value depends on what occurs academically and the quality of experiences provided subsequent to completion of the activity. It is imperative that a study be continued after concluding the discrepant event. Stopping an examination of the properties of air after the egg and bottle experiment constitutes an incorrect use of the discrepant event. An improper use of the discrepant

event could cause pupils to form a distorted view about the nature of science. Some pupils may conceive of science as a game, bag of tricks, or even a bit of magic. Students with such inaccurate perceptions are unlikely to view science either realistically or positively. Teachers should use, when beginning an area of study, the discrepant event rather than having the pupils read about science or define words and terms.

Gail Shroyer
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Factors Influencing Rural Science Improvement

This year-long study was designed to assess the community, organizational, professional, and procedural factors that influenced projects in their districts. Sixteen rural science teachers were selected and trained to plan and implement a science improvement project in their district.

Qualitative and quantitative data were collected pre-, during, and post-implementation to assess the factors that influenced the success of each improvement project. Surveys, interviews, site visitations, and numerous demographic and financial information were collected on each participant, their school, and community. These data were analyzed to determine the influence the organizational, community, professional, and procedural variables had on the level and degree of change in each district. The relationships between the independent and dependent variables were analyzed within and between all districts.

The results indicated that the successful utilization of teachers as leaders of science improvement projects was dependent upon a complex relationship between the individual, the school, and the community. Strengths in one area were limited by weaknesses in another. Overall, the organization exerted the greatest influence on degree of science impact on the field of education. There currently exists a great interest in the differentiation of teaching roles to encourage career ladders, master teachers, mentor teachers, and the overall "professionalization" of teaching. Current plans in this field, however, focus solely on the teacher. Little research exists assessing the factors that support the individual teacher in these new roles. This study demonstrated that science teachers can be effectively utilized to create powerful improvements in science education, especially at the elementary level. Many complex community, organizational, professional, and procedural factors must be understood and enhanced, however, before science teachers can be successful in this new improvement role.

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Developing Science Concept: Understandings in Small Rural Junior High Schools

The central research problem of this study can be stated as: what are the relationships between the intellectual levels at which students mentally function and the understandings they develop of the concrete formal concepts they study in science?

To gather the needed data, two validated measures of the students' levels of thought will be used: Mr. Tall-Mr. Short (Ratios) and Letters Task (combinational logic). To evaluate the content understandings each student has, we will prepare and validate four questions (2 concrete and 2 formal) in each content area--biology, chemistry, and physics--which assess understandings of specific concepts. The data on the performance of students on the questions measuring students' thought levels will be compared with the students' performances on the questions measuring conceptual understandings.

Final data will be collected late in the academic year in order to provide every student equal opportunity to study all the concepts. These data will be gathered in large schools (Tulsa) and small schools (numerous school districts, with middle school/junior high enrollments of less than 100 students, around the state of Oklahoma). Two-hundred eighth-grade students divided equally between small and large schools will comprise the sample. All schools in this study have adopted the same textbook, Principles of Science (Merrill).

What are the teaching implications for developing science concept understanding in small rural junior high schools? The presentation will thoroughly examine possible solutions for this question.

Emmett L. Wright
Curriculum and Instruction
Kansas State University
Manhattan, KS 66506

Organizing A Center for Science Education to Meet the Needs of Rural Science Teachers

With the rapidly expanding role of technology in modern life, the intellectual, political, and economic development of society is increasingly dependent upon engendering a scientifically literate citizenry. Unfortunately, as these concerns become ever more apparent, evidence suggests the scientific training of many students in our school systems lags well behind the broader state of scientific knowledge. In addition, the discrepancy between need and availability of qualified science teachers and quality science instruction continues to grow. The economic strength of

Kansas would be well served by a voting populace and work force with increased understanding of scientific concepts, principles, attitudes, and applications.

To better meet the needs of science teachers at all levels, including rural and small school science teachers, the Kansas Board of Regents in May, 1986 approved the establishment of the Kansas State University Center for Science Education. The Center for Science Education, administratively housed in its College of Education is organized to provide leadership in the area of science and environmental education in Kansas and the Plains States. Unique resources at Kansas State University provide a strong foundation upon which to base a concerted effort to improve teaching in the public schools.

The Center has three major functions: (1) Research--to document national, state, and local efforts to improve science education in schools and to provide the basic research to inform those efforts; (2) Development--to develop curriculum materials, pedagogical strategies, and organizational mechanisms and to demonstrate their effectiveness in model school sites; and (3) Dissemination--to disseminate the new knowledge and best experience to the audience of Kansas and regional school administrators, teachers, teacher trainers, researchers, and professionals in other related organizations and non-formal instructional settings.

RURAL EDUCATION: A HOPE FOR THE FUTURE

Ninth Annual
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Kansas State University
October 26-27, 1987

ABSTRACTS

Science Education Section
Conference Co-Chairpersons

Dr. Angelo Collins
Dr. J. Steven Oliver

Barbara Baldwin
Director of Instructional Services
KOOD-Channel 9
Bunker Hill, KS

Science Education Without Big City Hassle

Where do teachers go for fulfilling science programs when they do not have access to big city businesses, industry and resources?

Instructional Television, provided through area Public Broadcasting Stations, brings science into the classroom through a wide variety of exceptionally written and produced series. I.T.V. programs allow the child to explore the world of whales, see microscopic animals, explore space, all through television, a media that brings the pages of science alive with sound, color, and animation.

Find out how to tap into this inexpensive, proven method of motivating both students and teachers. Sample programs will be shown that stimulate the imagination, create awareness of the world, and involve the learner in new experiences that cannot be found in the pages of a book.

Betty L. Bitner and Billy H. Coyle
Southwestern Missouri State University
Springfield, MO

Application of the Bitner Thinking Model

Functioning in the "Information Age Society" necessitates information processing. Therefore, in order to produce scientifically and technologically literate citizens, teaching students how to think must be an integral component of a science curriculum.

The Bitner Thinking Model which attempts to coalesce aspects of different thought processes includes four major steps: (1) State the problem; (2) Search for the solutions; (3) Select and test the possible solution; and (4) Verify the results or conclusions. Within each major step, generic thinking tools such as observing, inferring, brainstorming, elaborating, and evaluating are used.

This unique demonstration will show the application of a thinking model to an actual tested General Science Course. It could be used as an introduction to any science or other course. The introduction to the thinking model is included as part of a "How We Learn" unit. This thinking model is used in a personal life application in a unit on "Self-Image". This unit is used to establish rapport with and caring from the teacher as well as showing how science instruction can be used in personal lives. In addition, the model will then be demonstrated in its use in a unit on measurement. This will show how the thinking model may be integrated easily into a regular course of study enhancing not only the regular skills of the course but, additionally, the most important skill -- Thinking!

BEST COPY AVAILABLE

Virginia Bryan, David Winnett,
and J. Edmund White
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Southern Illinois University
Edwardsville, IL

Science Activities for Elementary Grades Using Self-Contained Kits: Pre-Service and In-Service Preparation of Teachers

Science "kits" provide a practical method for introducing experimentation in the elementary classroom. We have worked on developing kits and preparing teachers to use the materials in their elementary classroom. Several school districts in this area have adopted a kit program. In-service workshops have prepared the teachers. Our pre-service elementary education science course introduces the kit concept by using special kits that have been developed for this course with hands-on activities. The content and approach are interdisciplinary, including both life and physical science.

Both sets of kits will be described, and activities for helping teachers to use them will be presented. Hand-outs describing the activities will be available.

Richard M. Busch and Larry Enochs
Departments of Curriculum and
Instruction and Geology
Kansas State University
Manhattan, KS

Use of Field Sites to Enhance Earth Science Education in Rural and Small Schools

Field sites are important tools for enhancing Earth Science education. They are easily accessible, often within walking distance of the classroom. They are also sources of free samples and information in outdoor settings where "hands-on" learning can be encouraged. We have found that students readily incorporate their own natural curiosity in exploring and evaluating field sites to obtain firsthand information and data. The field information and samples can subsequently be evaluated as classroom projects, laboratory projects, homework assignments, or science fair projects.

For example, we developed a short intensive field course designed to assist teachers in developing field sites of geological significance. Most rocky exposures near schools contain minerals, fossils, bedding planes, fractures, and other features that can be used for lessons on mineralogy, paleontology, rock identification/interpretation, relative age relationships, paleoecology, geological process, and geological methods. Teachers can also consult with university geology departments, state geological surveys, museums or rock and mineral clubs for more information about a field site currently being utilized or for information about additional field sites having special geological significance.

Bette J. Del Giorno
Fairfield Public Schools
Fairfield, CT

Using Community Resources to Effect a Successful Staff Development Program

Project NETWORKS for Science is a Staff Development program for teachers of science, K-12, and administrators in the Fairfield Public Schools, Fairfield Connecticut.

Project NETWORKS began as a pilot in the spring of 1986 and has been funded by a $265,608 2-year grant from NSF and a small Title II grant from the state as of July 1, 1986.

Fairfield is a coastal town with eight elementary (K-5), two middle (6-8) and two high schools. As of March 3, 1987 there were 6,247 students, 473.25 certified staff members, and 28.9 administrators. The Project's targets are the administrators, 131 elementary teachers, 17 middle school and 21 high school science teachers.

Project NETWORKS forms partnerships with many community resources and invites authorities in these cooperating agencies/institutions to offer staff development opportunities.

Since Project NETWORKS began in the spring of 1986, 62.5% of the elementary school teachers, 94.1% of the middle school, and 90.5% of the high school science teachers have participated. Eight-three elementary school persons spent 604 hours in staff development activities averaging 7.3 hours per participant. The 17 middle school staff spent 261 hours averaging 15.4 hours per participant and the 19 from the high schools spent 171 hours averaging nine hours per participant.

Kevin D. Finson
Valley City State College
Valley City, ND

An Earth Science Program for Inservice Elementary Teachers

In 1985 the North Dakota State Board of Higher Education identified needs of teachers in the state, with earth science as the science area most needed by those teachers. Further, the Board identified teachers of grades 5-8 as having the most critical needs for updating in this area. Consequently, one small college developed a program designed to meet these needs. It included not only earth science content, but also incorporation of several methodologies demonstrated in the past to be effective in science teaching. The program consisted of three two-part workshops on methodologies as well as one summer content course in earth science. Teacher concerns and attitudes were measured both before and following the program. Results indicated teacher attitudes became significantly more positive toward science, and concerns shifted away from those that were personal self-centered toward pupil-centered ones. This paper will explain the program in more detail and

look at the attitudinal and concerns-based changes in the participating teachers.

Eric Flescher
Shawnee Mission School District
Lawrence, KS

C.A.S.E. - Computer Assisted Science Education

This interactive interdisciplinary workshop will deal with astronomy and space sciences education and curriculum for grades elementary to high school. The main focus will be on the multidisciplinary nature of astronomy and space sciences education that can accomplish the following: (1) Utilize and integrate the other subject/content areas such as language arts, social studies, humanities, art, math, career awareness, and many other science areas; (2) Provide enrichment and skill building opportunities that will help promote creative, critical, and futuristic thinking; and (3) Provide meaningful opportunities for students to initiate, develop, and follow through with related activities, projects, and research and development activities.

The role of technology and computer assisted education (as a tutor, tool, tutee) will be stressed as a means to help integrate and promote this whole process. This will help provide novice, intermediate, and advanced computer users a better understanding of the variety of hardware and software (commercial and public domain) offerings and related techniques and methods that have been used to enrich this curriculum/program.

The presenter, a consultant/supervisor/teacher for science and gifted programs, K - college, in North Carolina, Michigan, and Kansas, was one of 180 educators throughout the United States to be chosen during 1986, for a special NASA sponsored program called NEWMAST, (NASA Educational Workshop for Mathematics and Science Teachers). In addition, he is a leader of a Young Astronauts chapter at the high school level and will also share information about successful programs initiated and NASA space curriculum activities, resources, and materials. The Space Shuttle/Space Station Involvement project will also be discussed.

Participants should come prepared to share ideas and information about their computer and/or space sciences involvement as well. Educators contributing written ideas and information will receive a compiled booklet of these ideas after the convention.

Rosemary Myers Hagg
I.T.V. Utilization and
Marketing Coordinator
Kansas City, MO

How I.T.V. Can Help Teach Science

Because research shows that many students are visual learners, effective use of audio-visuals when teaching science is essential. Instructional Television can assist teachers and students in trying to grasp an understanding of science concepts. Workshop participants will have the opportunity to view and discuss excerpts of I.T.V. programs specifically designed for the science classroom. Effective utilization techniques about how to implement the I.T.V. programs into a lesson plan will also be presented.

Roger Hoefer and Helen Unruh
Kansas Cosmosphere and Space Center
Hutchinson, KS

America's Manned Space Program: Our Students' Future

The mission of the Kansas Cosmosphere and Space Center (KCSC) is to stimulate public interest in the exploration of space by providing information, exhibits, and experiences that are educational and entertaining.

In support of the mission statement of the KCSC, the educational staff announces the development of Teacher In-service Training. It is the purpose of the KCSC to provide teachers with a more comprehensive background on the development, current status, and future of America's Manned Space Program. Seeing the need to encourage and enlighten today's students about their future in the space program, the purpose of Teacher In-service Training is two-fold:

1. Inform teachers and administrators about the four educational areas students can attend when planning a field trip to the Cosmosphere; and

2. The KCSC staff has developed a series of space-related workshops and astronomy-related planetarium programs, specifically for teachers.

By participating in the Conference on Rural and Small Schools, we would hope to give teachers the opportunity to implement space science curriculum into their classroom. This can best be accomplished by discussing with teachers our In-service Training Program.

Boyd D. Holton
West Virginia University
Morgantown, WV

What Professional Journals Do Mathematics Teachers Read?

One of the objectives of the 1987 Rural and Small Schools Conference is to consider the problem of overcoming professional isolationism of the rural math and science teachers. Reading professional journals and participating in professional organizations may play an important role in decreasing the professional isolationism.

As a part of a survey sent to over 1000 secondary mathematics teachers in a state, more than 600 teachers responded to items concerning the types of professional mathematics education journals they regularly read. These responses will be reported at the conference as well as relationships with other demographic information collected in the study, such as years of teaching and professional training.

Jerry Jinks
Russell H. Lord
Eastern Montana College
Billings, MT

The Montana Better Elementary Science Teaching Projects

This report describes the Montana Better Elementary Science Teaching Project (BEST), a three year, federally funded in-service effort. Three of the University system's six units, the State Office of Public Instruction, and the Montana Science Teachers Association are cooperating in the use of computer technology to overcome the geological isolation so frequent in Montana. One hundred and fifty "Science Advocates" will upgrade and update their science content in Biology/Life Sciences, Earth Science, Chemistry, Physics, and Space Science by completing four week-long summer institutes. They will return to their home districts as resource personnel who participate in a state-wide "electronic bulletin board" that serves as a network link among BEST participants and staff. Evaluation of the BEST Project consists of a content specific test, the Science Knowledge Test (SKOT), that was developed for this project, and a questionnaire assessing each BEST participant's scheme for science and self-efficacy for science teaching. Results of the first year evaluation will be included in this report.

Brenda K. Johnson
Volin, SD

"Teachable Moments" in Rural and Small Schools: Teacher and Administrator Perspectives

Flexible learning opportunities are a unique resource of the rural or small school. Mixing classroom learning with "real world" or clinical experiences stimulates interest and provides deeper understanding of abstract concepts. I'll describe several ideas that I have implemented and observed from others in South Dakota. Teaching and administration of the ideas will be addressed. Participants are also encouraged to share ideas.

Howard S. Kimmel and Mark O'Shea
New Jersey Institute of Technology
Newark, NJ

Telecommunications: Improving Science Education in Rural School Settings

Rural school systems and small schools suffer the same in-service and curriculum improvement problems as those experienced by the larger urban and suburban school systems, only to a greater degree. A collaborative effort of New Jersey Institute of Technology's Center for Pre-College Programs and Fairleigh Dickinson University's School of Education uses electronic conferencing in support of teacher professional development and curriculum improvement in schools in Central and Northern New Jersey.

This network of secondary grade level science teachers and university faculty addresses the problem of isolation of teachers from resources outside their immediate teaching environment, as well as the major identified root of the failure to implement the curricula - the lack of continuing support and assistance during the implementation process. The implementation of new curricula is generally an isolated event within a single district. This effort has initiated inter-district cooperation and participation in curriculum and resource development in a way that no longer has imposed geographical limitations of school district, regional, or state boundaries.

The diversity of activities of the network will be highlighted. Problems associated with startup and continuance of electronic networking will be discussed also. The model should be applicable across all grade levels.

Richard P. Olenick
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University of Dallas
Irving, TX

The Mechanical Universe and Beyond: Physics for Science Teachers

An exciting project consisting of videotapes on introductory calculus-based college physics and high school adaptations that were developed at Caltech, The Mechanical Universe and Beyond..., serves as an excellent model for pre-service and in-service preparations of rural and small school science

teachers. The college series, which consists of fifty-two half hour programs and accompanying textbooks, covers the subject matter found in most introductory physics courses: classical mechanics, thermodynamics, electricity, magnetism, relativity, and quantum physics. However, it takes a unique approach to the subject. Through liberal use of computer animation, historical re-enactments, and applications to everyday phenomena, this series aims to use effectively the television medium as a tool to communicate physics. This approach can help overcome the professional isolationism of the rural and small school science teacher by providing fresh approaches to classical topics in physics that can be viewed over television. The adaptations of the videotapes for use in high school physics courses have accompanying written support materials that aid teachers in presenting selected topics of the series. These materials have been evaluated by hundreds of teachers and thousands of students across the country and have been shown not only to be fascinating and motivating but also to promote students' conceptual understanding. The background, goals, and evaluation data of this project will be discussed. Programs and written materials from the series will be shown.

Paul B. Otto
University of South Dakota
Vermillion, SD

Mastery of the Possibilities

Mastery Learning has been identified as one of two programs in Science Education as bringing about effective changes in student achievement. A Mastery Learning program was implemented in the ninth grade physical science classes of a high school in southeastern South Dakota located in a community of 12,000 population. An evaluation was conducted after three semesters of the program. Advantages and disadvantages to Mastery Learning in a ninth grade physical science class have been identified. Implication for utilization in other schools will be discussed.

Lawton Owen
Kansas Wesleyan
Salina, KS

Overcoming Professional Isolation and Keeping Up in Your Discipline

The causes of these two interconnected problems will be explored. Solutions which have been used by others will be presented. Those attending the session then will react to the ideas presented and share their methods of overcoming these two problems. The group also will suggest how others might help.

E. Joseph Piel
State University of New York
Stonybrook, NY

Teaching Science Through Science Technology Society

In rural and small schools it is not always possible to introduce specific S-T-S courses because of size of student body and staff. This limitation should not preclude the use of technology society situations as a means of teaching science in the science course already scheduled in the curriculum.

This presentation/workshop will introduce a means of using technology society problems in science classes. Specific situations involving biology, chemistry, earth science, and/or physics will be presented. The participants will be involved in student activities in the area of their specialty. Topics to be presented with classroom materials are the following: water supply problems, auto safety, population modeling, and space program spin-offs.

J. Preston Prather
Robert L. Hartshorn
Center of Excellence for Enrichment
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University of Tennessee
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Leadership Team Development: Hope for the Future of Elementary Science Instruction in Rural and Small School Systems

There is an urgent need for improvement in science education (National Commission on Excellence in Education, 1983). Many elementary teachers feel unqualified to teach science, and too many either devote little time to science instruction or ignore it completely (National Science Teachers Association, 1985). Elementary science education was"once a top priority and the source of a great deal of national enthusiasm and federal funding" (Mechlin and Oliver, 1983, p. 40), but relatively little attention has been given to improving elementary science instruction over the past two decades. As a result, the needs of many elementary teachers have been overlooked at a time when the importance of a sound elementary science background is becoming increasingly obvious. The problem may be especially severe in small, isolated school systems that lack an adequately trained supervisor of science instruction or other science specialist to facilitate the inservice training needed to correct the situation.

The University of Tennessee at Martin (UTM) developed a program to help train local teams of educators with the knowledge of science content, inservice training techniques, and principles of educational planning and administration required to establish and maintain effective elementary science programs. Numerous studies had indicated the critical role the principal's leadership played in the success of any school program, but "many principals feel uncomfortable, even inadequate, with science" (Mechlin and

Oliver, 1982, p. 4). The project provided for joint training of teachers, principals, and supervisors to insure the combination of local instructional and administrative capability needed for planning, implementation, and maintenance of effective elementary science programs in rural school systems. Although the program was conceived from the perspective of elementary education, the strategy for developing a nucleus of leadership within the local school system would be applicable to all levels of pre-college science instruction.

The project, which was funded by the National Science Foundation and Tennessee Higher Education Commission, provided for participation of nine 4-member teams from nine geographically dispersed rural or small school systems within a 32-county area and covering approximately half the State of Tennessee. Each team consisted of a primary (grades K-3) and an intermediate (grades 4-6) teacher, their building principal, and their system's supervisor of instruction. Applications for the program were accepted only from school systems willing to make a commitment to hands-on methods of science instruction.

The project comprised two parts: 1) an Elementary Science Education Institute, which provided an intensive program of academic preparation for the team members, who participated as coequals in all facets of the training; and 2) a Field Phase to be carried out by the teams in their respective school systems and educational development districts during the following school year. The Institute included instruction in the sciences, hands-on methods of science teaching, computer literacy, leadership and communication, and educational program planning and development. Each team was required to plan a one-year field project, and instruction in the principles of adult education was provided to prepare them to assume an inservice training role. Participants also were trained in use of the Science Activities Manual K-6, an activity-oriented manual for hands-on science instruction developed by the UTM Center of Excellence for the Enrichment of Science and Mathematics Education.

Following the Institute, each team implemented its field project, a local program for improvement of elementary science instruction planned on the basis of independent, on-site research conducted as part of the training in educational planning. As part of the field activity, each team was prepared to train other teams in anticipation of a ripple effect culminating in improvement of elementary science instruction throughout the state. Grant funds provided for employment and training of three exemplary elementary teachers with extensive science teaching experience to assist the project staff in providing a one-year support system for the local team activities.

This presentation will explain the nature and scope of the project, including the principles of grass-roots educational leadership, team structure, and educational need upon which it wa conceived and justified. The nine field projects developed by the trams will be reviewed and other benefits of the project for rural schools will be examined from the perspective of team experiences, analysis of teacher performance and attitude, and other data. Suggestions for replication will be included.

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Ronald Ronau
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University of Louisville
Louisville, KY

The Physics of Supernormal Activities
OR
What Does Superman Eat For Breakfast?

Superman, on his way to work in the morning, slips quietly into a Metropolis diner for breakfast. If he expects a normal day's activities such as stopping a speeding train (more powerful than a locomotive), jumping over a tall building in a single bound, and flying faster than a speeding bullet, what should he order for breakfast? Sound superfluous? Assuming that Superman performs his feats by physical rather than magical means, consider the energy required to carry out his daily activities.

This presentation will explore the energy required for Superman to perform such feats under the rules of physics. Computer programs were developed to assist in the investigation and will be demonstrated.

Wayne E. Sirmon
Mary-Michael Campbell
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Mobile, AL

Science In-Service in Southwestern Alabama

The South Alabama Research and Inservice Center (SARIC) was established by the Alabama Governor's Education Reform Commission in the Spring of 1985 as one of eleven regional inservice centers. Approximately 50% of the 5,000 K-12 teachers in the five county SARIC service area teach in a rural setting.

During the first 22 months of operation, SARIC conducted over 36,000 teacher-hours of training, In a year-round effort, over 65 science programs have been conducted with a total enrollment of 1,800 teachers. A wide variety of delivery methods have been employed to address the needs of a diverse population of teachers. The relative merits of on-site, university campus, and field experience programs will be discussed. Program experience has been gained with activities ranging from two hour after-school sessions to four day university-based workshops.

SARIC has successfully utilized computer registration, desktop publishing, and a needs-assessment data base for targeting selected individuals for special interest programs. The difficulties encountered with communication, logistics, and planning resulting from year-by-year funding will be reviewed.

Current efforts to build esprit among the region's science (and science-oriented) teachers center on curriculum development workshops. These programs include activities which seek to establish a sense of "belonging" to a regional network of science teachers, as well as the more typical materials development and demonstration lesson plans.

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